NOV 27 1916
UNIV. OF MICH.
LIBRARY

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· DECEMBER · 1916 ·

ANNUAL MEETING, NEW YORK CITY, DECEMBER 4-8

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLISHED MONTHLY BY
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 W. 39th Street, New York

Papers to Come: Copy Must Be in Hand
Not Later Than
Proposed Papers: See Page Advertising Section
Abstracts Should Be Sent In Early

The Society as a Body Is Not Responsible for the Statements and Opinions Advanced in Papers or Discussions. (Code)

VOLUME 38 DECEMBER, 1916 NUMBER 12

CONTENTS OF THIS ISSUE

PROCEEDINGS OF SECTIONS
Annual Meeting Papers
Miscellaneous Papers
Graphic Statistics of Accidents in the Design and Operation of Steam Power Plants. By J. S. [illegible]
The Place of Art and Beauty Through Utility. By [illegible]
Steam-Plant Economy. By [illegible]
Aviation Papers
The Relation Between Horizontal Inertia, Vertical Inertia, and Weight. By [illegible]
Miscellaneous Papers
Standardization of Machine Tools. By [illegible]
Ratio [illegible]
Aviation Papers
Miscellaneous Papers
Aviation Papers
Miscellaneous Papers
Aviation Papers
Miscellaneous Papers

The Thirty-Seventh Annual Meeting

New York, December 5-8, 1916

THE thirty-seventh Annual Meeting will be held in the Engineering Societies Building, 29 West 39th Street, New York, beginning on Tuesday, December 5, and ending on Friday, December 8. Every member of the Society should make a special effort to attend the meeting, and the Society, in the spirit of its policy of service to the engineering profession, extends a cordial invitation to every other engineer to be present.

All the events this year will be held in the Engineering Societies Building, either in the Auditorium or in the Assembly Rooms on the Fifth Floor. The rooms of the Society will be open as usual and members are invited to make themselves thoroughly at home.

LEADING EVENTS

Tuesday, December 5

Headquarters will open for registration at 12 noon.

In the evening, the President, Dr. D. S. Jacobus, will deliver the annual address, his subject being The Relation of Education to Engineering. This will be followed by the annual report of the Tellers of Election of Officers, the introduction of the President-Elect, and a reception to the President, President-Elect, ladies, members and guests.

Wednesday, December 6

A business meeting will be held in the morning; at this the Annual Report of the Council will be presented, etc., and the awards of Junior and Student Prizes will be made.

The business of this meeting will be suspended at a certain hour to hold exercises in honor of the memory of the late Dr. John E. Sweet, Past-President, Honorary Member and founder of the society.

Two professional sessions will then be held, one for the presentation of papers on steam engineering subjects, papers contributed by local sections, and papers awarded prizes this year and one in charge of the Committee on Protection of Industrial Workers.

In the afternoon there will be three simultaneous professional sessions. One of these will be held under the auspices of the Textile Committee and one in charge of the Machine Shop Practice Committee; the third will be devoted to power-plant papers.

The ladies will give a Musicale and Tea in the afternoon, to which all are invited, both ladies and gentlemen.

On Wednesday evening a members' get-together, get-acquainted Smoker will be held. This will be in charge of the New York Local Committee as last year, and every member is invited for a social evening and a good time. Frank B. Gilbreth, Mem.Am.Soc.M.E., will relate his experiences in Europe during the war.

Thursday, December 7

Morning and afternoon there will be professional sessions for the presentation and discussion of papers on Valuation of Industrial Property. These sessions have been arranged by the Committee on Meetings, which will have charge of them.

In the afternoon there will be a professional session in charge of the Gas Power Committee.

Excursions to points of engineering interest in New York and vicinity have been planned for Thursday afternoon.

In the evening a Popular Lecture has been arranged. This will be followed by the Annual Reunion and Dance.

Friday, December 8

Three professional sessions will be held on Friday morning. One of these will be in charge of the Railroad Committee, one in charge of the Boiler Code Committee, and the third will be devoted to miscellaneous papers.

In the afternoon there will be a Public Hearing on the A.S.M.E. Boiler Code. This is open to all persons interested, to whom upon request special invitations will be sent. The hearing will be continued on Saturday morning.

Advance Copies of Papers

Papers to be presented have been printed in pamphlet form for advance distribution, and copies of any of the papers will be sent to members before the meeting gratis upon application. Titles of the papers are given in the program printed in the Society Affairs Section of this issue of The Journal. Abridgements of the papers are published in the November and December issues.

Entertainment Features

On Wednesday afternoon a Musicale and Tea will be given to the visiting ladies, members and guests. This will be under the auspices of the Ladies' Committee. This event is one of the delightful social features of the convention, and all are cordially invited to attend.

Special attention is called to the Smoker on Wednesday evening. This event is distinctly a members' reunion, and the New York Local Committee promises the members a repetition of the good time had last year.

An important social event this year is the Annual Reunion and Dance to be held on the Fifth Floor of the Engineering Societies Building, following the Thursday evening lecture. This is an innovation, and has been made possible by the recent structural changes in the assembly rooms on this floor and the laying of a dance floor.

Excursions

As last year, the plan is to have a few excursions of exceptional interest. It is contemplated that visits may be made to the Essex Power Station of the Public Service Corporation, Harrison, N. J., the Brooklyn Navy Yard, Station B of the New York Steam Company, the Loose-Wiles Biscuit Company, the Otis Elevator Company, the Bush Terminal, the Stephens Milk Co., and Columbia University.

One large office building—probably the Equitable Trust Co.'s Building, the largest office building in the world—will be visited, also one telephone building.

Conferences of Sections

Conferences of official delegates from local Sections of the Society with each other and with the Officers and Council will be held Tuesday, Wednesday and Thursday afternoons. They will be preceded each day by a luncheon.

Delegates from Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, Minnesota, New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester are expected.

Student Branch Conference

A Conference of Student Branch representatives will be held on Wednesday afternoon. Delegates from the forty affiliated Student Branches at universities giving courses in mechanical engineering subjects are expected.

College Reunions

The New York Alumni Association of various colleges where technical courses are given will hold reunions on "College Reunion Night," which this year is on December 8.

The Alumni of Brown University, Cornell University, Lehigh University, Brooklyn Polytechnic Institute and the University of Illinois have planned reunions this year.

Members of the Society and their friends are invited to these reunions.

November....., 1916

To The Secretary of The American Society of Mechanical Engineers,
29 West 39th Street, New York.

Please send me the following Annual Meeting papers

.....

.....

.....

Signed .....

Address .....

COMING MEETINGS OF THE SOCIETY

Philadelphia, Pa., November 28, 1916. Subject: Aeroplane Engines, by Howard Huntington, Secretary of the Aero Club of America.

Buffalo, N. Y., November 29, 1916. Subject: C. H. Bierbaum, Mem. Am. Soc. M. E., will talk on his recent research work on Graphite.

Buffalo, N. Y., December 13, 1916. Russell Huff, Mem. Am. Soc. M. E., president of the Society of Automobile Engineers and chief engineer of Dodge Brothers, will speak on A Plea for the Four-Cylinder Engine.

Philadelphia, Pa., December 14, 1916. Joint meeting with The Franklin Institute of the State of Pennsylvania. Subject: The Cooling of Water for Power-Plant Purposes, by Carl C. Thomas, Mem. Am. Soc. M. E., Professor of Mechanical Engineering at Johns Hopkins University.

THE SPRING MEETING

The Spring Meeting, 1917, of The American Society of Mechanical Engineers, will be held in Cincinnati, Ohio, on May 22 to 25. The Cincinnati local committee will coöperate with the Committee on Meetings in arranging the program.

Members of the Society and others are invited to contribute papers for consideration for presentation at this meeting. All correspondence regarding such papers should be addressed to the Secretary and will be referred to the Meetings Committee.

ANNUAL MEETING PAPERS

Continuation of Comprehensive Abstracts of Papers to be Presented and Discussed at the Thirty-Seventh Annual Meeting of the Society, New York, December 5 to 8, 1916

COMPREHENSIVE abstracts of the papers to be presented and discussed at the forthcoming thirty-seventh Annual Meeting of The American Society of Mechanical Engineers, to be held in the Engineering Societies Building, New York City, December 5 to 8, 1916, are given below. This publication of abstracts is continued from the November issue of The Journal.

These abridgments have been prepared with the collaboration of authors, and are therefore authoritative presentations of the subject-matter of the papers. In many cases the abstract comprises practically the entire paper, with the omission of only such sections as mathematical derivation of formulæ, minute descriptions of apparatus, and logs of tests.

Engineers—members of the Society and others—are invited to contribute discussion to these papers. Such discussion will be read at the meeting and be published in The Journal.

All the papers printed below are also being printed in unabridged form in pamphlet size, and members of the Society desiring a pamphlet copy of any particular paper may obtain it gratis upon application to the Secretary.

The order of presentation of papers is given in the program included in the Society Affairs section of this issue. The first papers below are to be presented at the Miscellaneous Sessions.

Two of the papers to be presented at the Railroad Session were published last month, as also was the Safety Code on Cranes to be discussed at the Industrial Safety Session, two of the papers to be presented at the Valuation Session, two of the Gas Power Session papers and one of the Textile Session papers.

GRAPHIC METHODS OF ANALYSIS IN THE DESIGN AND OPERATION OF STEAM POWER PLANTS

By R. J. S. PIGOTT, BRIDGEPORT, CONN.

Associate-Member

THIS paper considers the application of graphic methods of analysis of steam power plant design and operation to:

a The 90,000-kw. addition to the 74th Street Station of the Interborough Rapid Transit Company, New York City, where the entire output is electrical energy from three 30,000-kw. turbine-driven units, and

b The power plant of the Remington Arms and Ammunition Company, Bridgeport, Conn., where there is a variable output of electrical energy from five turbine-driven units of different capacities, and steam for industrial purposes and heating, this latter output fluctuating, naturally, with the seasons.

This abstract contains the essential facts and conclusions in those paragraphs in the paper dealing with the Interborough addition. The Remington Company's plant is omitted.

For presentation at the Annual Meeting, December, 1916, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

THE INTERBOROUGH ADDITION

Individual water rates. The Willans input-output lines have been employed considerably in connection with the performance of steam turbines and steam engines, but for a complete analysis it is necessary also to have input-output lines for:

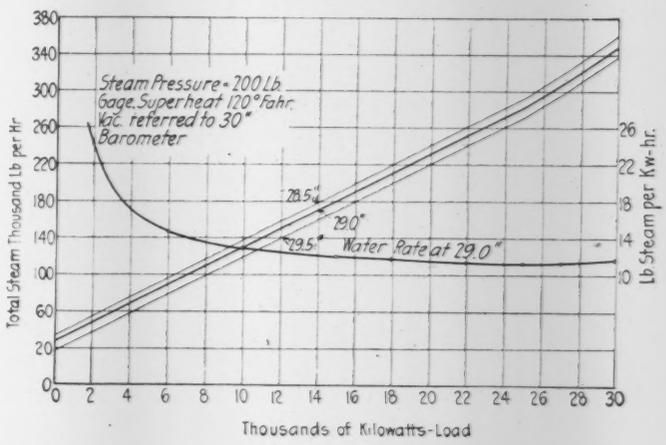

Steam Pressure = 200 Lb Gage. Superheat 120° Fahr. Vac. referred to 30" Barometer
28.5"
29.0"
29.5"
Water Rate at 29.0"
Total Steam Thousand Lb per Hr
Lb Steam per Kw-hr.
Thousands of Kilowatts-Load

FIG. 1 WILLANS LINES AND WATER RATE, 30,000-KW. WESTINGHOUSE TURBINE UNIT

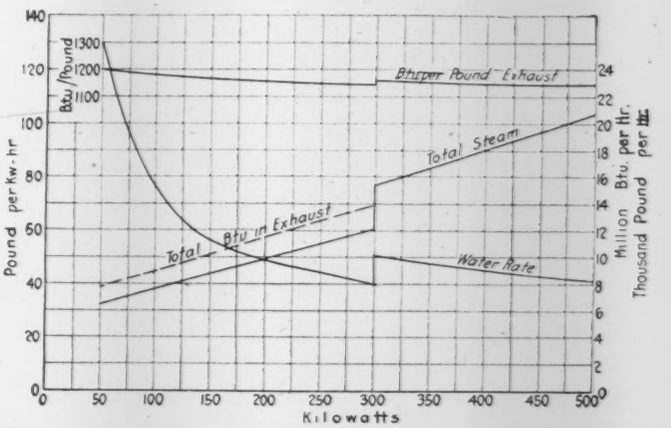


FIG. 2 INPUT-OUTPUT LINE AND ECONOMY, 300-KW. EXCITERS

a main units, *b* exciters, *c* boiler-feed pumps, *d* forced-draft fans, *e* stoker drive, *f* boilers.

Main units. The Willans lines and water-rate curves for the 30,000- kw. Interborough steam turbines are shown in Fig. 1. Here it will be seen that the effect of variation in vacuum is a practically constant variation in the amount of total steam required over the entire range of operation. The percentage increase in economy is greater at light than at heavy loads.

Exciters. In Fig. 2 will be found the Willans line and water-rate curves of a 300-kw. turbine-driven, geared, exciter set. The machine is arranged with a special oversize generator and overload valve, so that, in the event of the failure of one of the two exciters to operate, the remaining one can carry the

entire load for a convenient length of time. It is not intended to use the range from 300 to 500 kw. in regular service.

Boiler-feed pumps. Willans lines for a 1000-gal.-per-min. turbine-driven boiler-feed pump are given in Fig. 3. The high no-output steam consumption is characteristic of all constant-pressure, turbine-driven centrifugal pumps, in which the efficiency drops off rapidly at the lower loads. Most boiler-feed centrifugal pumps show from 40 to 45 per cent full-load brake horsepower at no load, and from 50 to 60 per cent full-load steam consumption. The Willans lines for most turbine-driven centrifugal pumps show a greater curvature than those of Fig. 3.

Forced-draft fans. The curve in Fig. 4 is the input-output

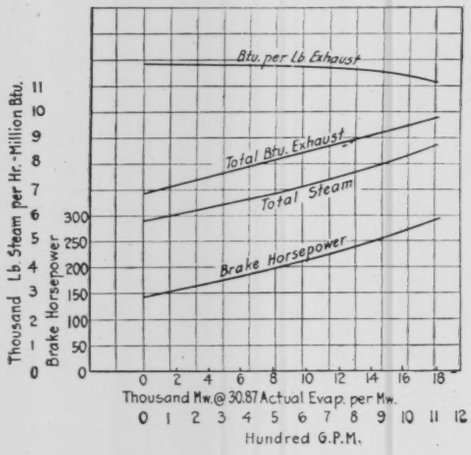


FIG. 3 INPUT-OUTPUT LINE AND BRAKE HORSEPOWER, 1000-G.P.M. BOILER-FEED PUMP

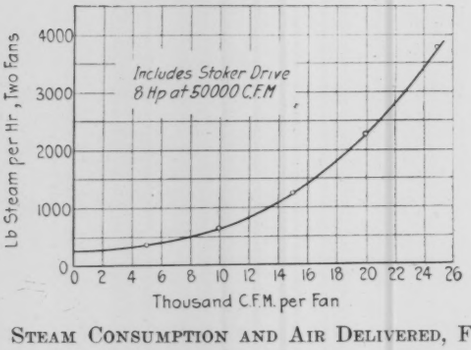


FIG. 4 STEAM CONSUMPTION AND AIR DELIVERED, FORCED-DRAFT BLOWERS

curve of the forced-draft fans. The units are arranged so that two multivane fans are driven by a single turbine. One unit serves a battery of two boilers through short air ducts. The sharp curvature is due to the fact that both pressure and volume of air increase with the speed. The curve is drawn on the basis of the steam consumed by both fans, and the air delivered by each. The mechanical stokers are driven from the fan shaft, requiring about 8 h.p. per pair at 50,000 cu. ft. per min. air delivery; this value is from tests.

The volume, static pressure and brake horsepower required by fans for the 520-myriawatt[1] B. and W. boiler using the Taylor stoker are given in Fig. 5, on a basis of 17 lb. of air per pound of coal. The results of numerous tests show that the CO_2 content, and consequently the air per pound of fuel, is substantially independent of the rate of driving with underfeed stokers.

From Figs. 4 and 5, Fig. 6 has been constructed, showing

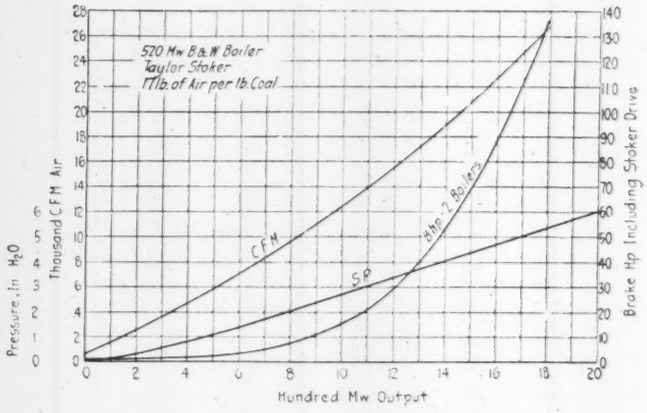


FIG. 5 AIR, BLAST PRESSURE AND BRAKE HORSEPOWER, FORCED-DRAFT FAN

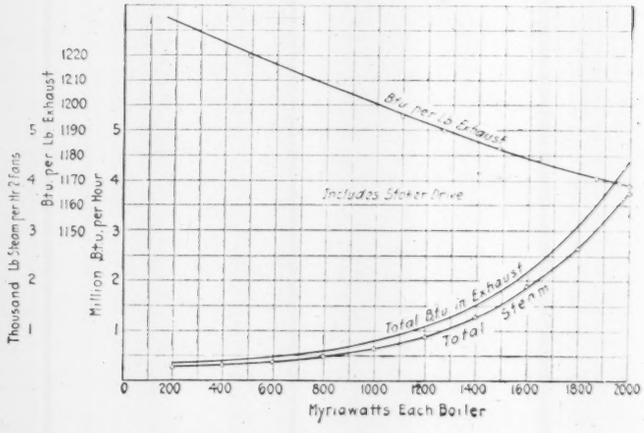


FIG. 6 STEAM CONSUMPTION AND BOILER OUTPUT, FORCED-DRAFT BLOWERS

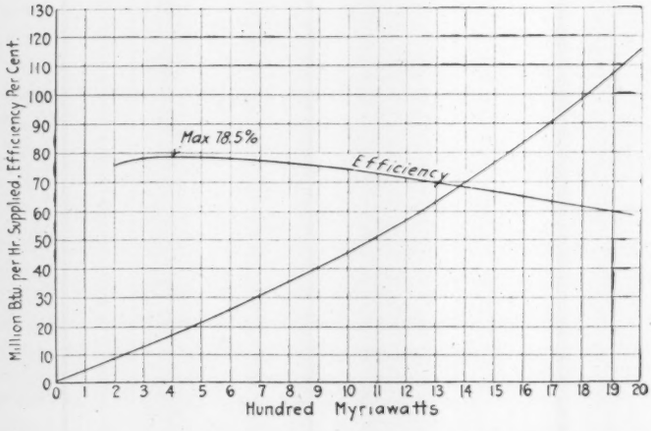


FIG. 7 BOILER INPUT-OUTPUT CURVE AND EFFICIENCY, FROM TESTS

the relation between the steam consumed by the fans and the boiler output in myriawatts.

Boilers. In Fig. 7, the input-output curve of a single boiler

[1] The unit called "myriawatt" has been suggested by some engineers as a unit of boiler capacity. It is 2 per cent greater than the "boiler horsepower" and is equivalent to 34,150 B.t.u. per hour, the "boiler horsepower" being 33,479 B.t.u. per hour.

is plotted from data obtained from actual tests. The efficiency at different rates of output is also shown, the maximum being 78.5 per cent; higher efficiencies are frequently obtained in single tests, but the values given represent the average of the best results obtainable in practice.

Condensers. The Willans lines for the condenser auxiliaries are not essential, as the condenser operates at practically full

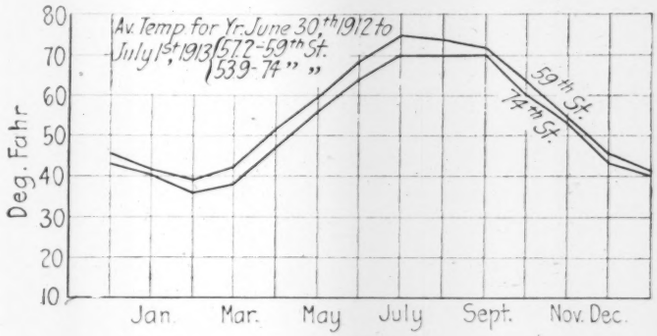


FIG. 8 CIRCULATING-WATER INJECTION TEMPERATURE

load, once it is started. The variation in cooling-water temperature is shown in Fig. 8. The average for the year, June 30, 1912, to July 1, 1913, at the 74th Street Station of the Interborough Rapid Transit Company, was 53.9 deg. fahr.

Construction of the combined curves. Fig. 9 shows the heat input per hour plotted against myriawatt output of 30 active boilers, 520 myriawatts rated capacity each. Theoretically, the most economical method is to reduce to zero load with all

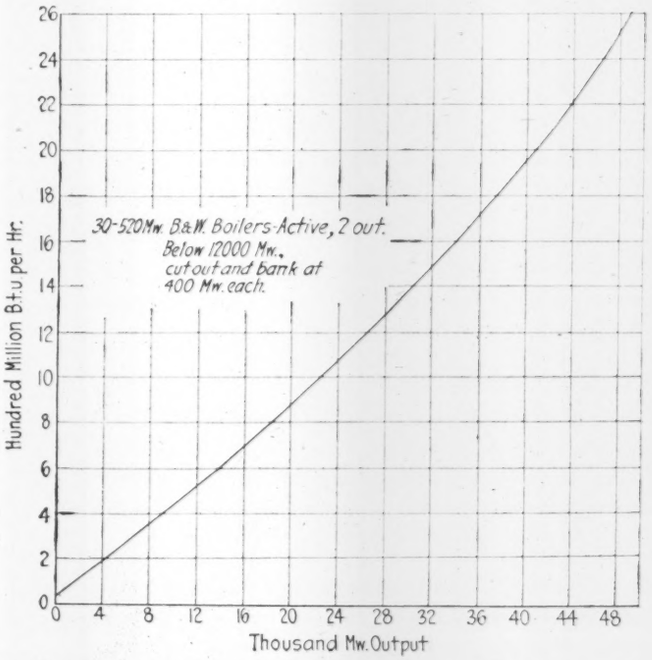

30-520 Mw. B&W. Boilers-Active, 2 out.
Below 12000 Mw., cut out and bank at 400 Mw. each.
Hundred Million B.t.u per Hr.
Thousand Mw. Output

FIG. 9 BOILER-ROOM INPUT-OUTPUT LINE

boilers active, banking none. It is not feasible to operate in this manner, however, because of the difficulties of operating the underfeed stoker at loads less than 80 per cent of capacity and the question of labor costs. Fig 9 is therefore drawn on a basis of cutting out and banking as the load drops from 12,000 myriawatts at a rate of one boiler for every 400-myriawatt drop. This method is only slightly less efficient than continuous operation of all boilers.

Combined boiler-room auxiliaries, input-output lines. In Fig. 10 are combined the curves of Figs. 3 and 6 to give the total steam consumed by boiler-feed pumps, fans and stoker drives against gross output of the boilers in myriawatts, and the total B.t.u. available in the exhaust steam from these auxiliaries. It will be noticed that, for normal loads, the steam consumption of the boiler-room auxiliaries varies but little

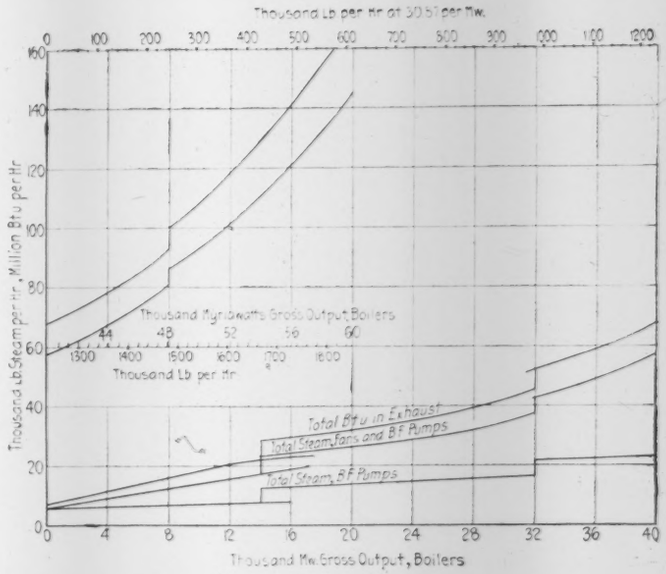

Thousand Lb per Hr at 30 lb per Mw.
Thousand Lb Steam per Hr., Million B.t.u per Hr.
Thousand Myriawatts Gross Output, Boilers
Thousand Lb per Hr
Total B.t.u in Exhaust
Total Steam, Fans and B.F. Pumps
Total Steam, B.F. Pumps
Thousand Mw. Gross Output, Boilers

FIG. 10 BOILER-ROOM AUXILIARY INPUT-OUTPUT LINES

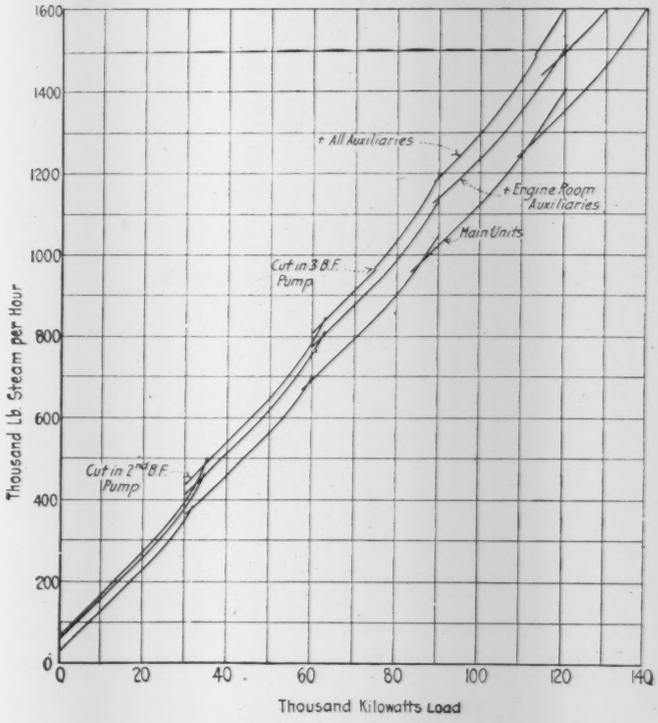


FIG. 11 ENGINE-ROOM STEAM DEMAND

from 4.6 per cent of the total steam generated. All except about 3 per cent of the losses in a steam turbine reappear as heat in the exhaust. Therefore, *Heat in exhaust = Total heat in steam supplied* — (3 *to* 4.5 *per cent*) — *Brake horsepower* × 2547 — 3,200,000 *B.t.u.* The 3,200,000 B.t.u. covers radiation and leakage from the exhaust system. This radiation loss

is figured, if possible, from area of pipe-line surface; but for quick figures, 2 per cent of the heat of steam passing at full load will amply cover this loss, both on high-pressure and exhaust steam. Usually it does not actually exceed 1 to 1.5 per cent.

Total steam demand. The total steam demand for the main turbine units in pounds per kilowatt-hour developed is shown in one of the curves of Fig. 11, marked "main units." All curves on this sheet are based upon a 29-in. vacuum, and the circulating water is assumed to be at a constant temperature from May 1 to November 1, and at another temperature for the rest of the year. In Fig. 11, the curve marked "main units" is obtained directly from Fig. 1. Adding 21,620 lb. of steam per hour per unit for the condenser auxiliaries, which comprise two 37,500-gal.-per-min. circulating pumps, two 800-gal.-per-min. hot-well pumps, and one dry vacuum pump for each unit, gives the curve "engine-room auxiliaries." Adding the boiler-room-auxiliary steam demand, gives "all auxiliaries." There are also added 3 per cent for starting, warming up, and losses dependent upon load; and 25,000 lb. of steam per hour for pipe radiation, boiler dusting and leakage. These last are substantially independent of the load. From Figs. 10 and 11 the heat demand is drawn in Fig. 13, heat units of input being plotted against kilowatts output.

Bleeding. The curves at the bottom of Fig. 13 show the heat units required in the feed-water heater and the heat units available from the exhaust from auxiliaries per kilowatt of output.

Effect of bleeding. The effects of introducing or removing steam from a compound turbine are shown in Fig. 12. Here are shown the Willans lines of the high- and low-pressure turbines and entire unit, with and without bleeding.

It will be noticed that the straight Willans line for the low-pressure turbine is represented by the equation

$$W = 45{,}000 + 20.26\,L$$

in which W = total pounds steam consumed
L = kilowatt output of low-pressure turbine only
45,000 = no-load steam consumption, pounds.

Therefore, the addition of steam in any reasonable quantity at any load will produce the same kilowatt increase in output of the low-pressure turbine, at a water rate of 20.26 lb. of steam per kw-hr. The decrease of output of the high-pressure turbine, due to increased back pressure, is practically in the ratio of the adiabatic heat drop.

Balanced input-output curve. From the anticipated load

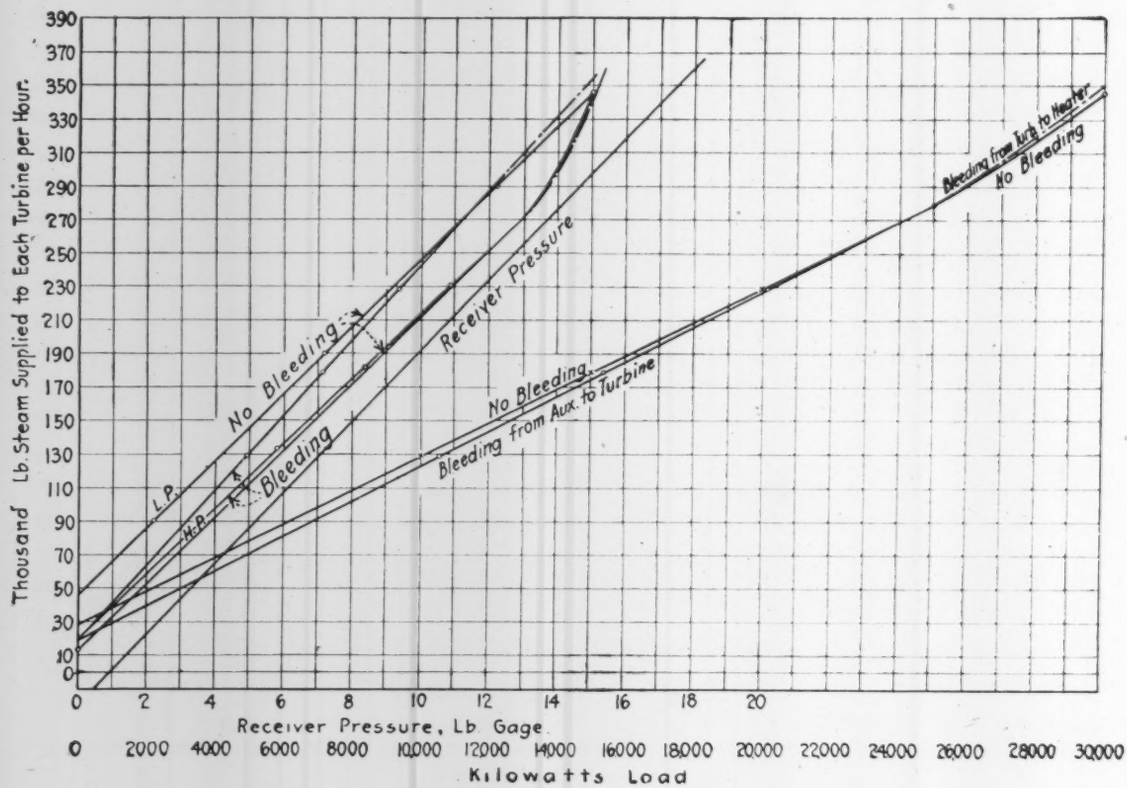


FIG. 12 CORRECTED WILLANS LINES FOR HEAT BALANCING

curve, Fig. 14, and from Figs. 9 and 13, the B.t.u. consumption for the two conditions is obtained. The data are: 40,739 kw. average load, 71,900 maximum hours, 977,735 kw-hr. per day total output. From Fig. 13, without heat balancing, the total input, at 40,739 kw. output, is 19,823,300,000 B.t.u. per day, while with heat balancing this amount is 19,636,800,000 B.t.u. per day. With coal at \$0.10 per million B.t.u. and such labor as is affected, which brings the cost up to \$0.11, the saving due to heat balancing is \$204.00 per day.

Effect of changing operating conditions. The Interborough installation considered in this paper is capable of peak loads of 90,000 kw. because there is adequate reserve in reciprocating-engine units.

The Interborough station is now running 22,500 B.t.u. per net kilowatt-hour, or 91 per cent of what is possible with the equipment. The effect of vacuum improvement can be obtained readily by shifting the heat- and steam-consumption scales of Fig. 13 up or down as required.

The correction for superheat can be applied as a direct

percentage correction to the total figures obtained from the load curve.

Electric-driven auxiliaries. Fig. 15 shows conclusively that this arrangement is thermally less economical than the steam-driven. The cost of the steam auxiliary station per effective installed kilowatt is $65.00 against $69.10 for the electric auxiliary station.

Consider a separate turbine-driven generating equipment for serving motor-driven auxiliaries and exhausting its steam into the feed-water heater and an economizer.

A load of 50,000 kw. will give about the best economy for both steam and electric drive. The data are: Main steam units, 561,200 lb. of steam, auxiliary power requirements, 1989 kw., 52,140 lb. of steam, including induced-draft fans and economizer-scraper drive. In the steam-electric units the temperature of the feed water would be raised from 70 to 155 deg. fahr. by the exhaust from the auxiliary turbines, and the possible rise in the economizer would be 147 deg. fahr. (flue-gas temperature cannot be brought lower than 150 deg. fahr. above water temperature). The use of the economizer will lower the B.t.u. per kilowatt-hour to 18,000, as against 19,250 without it, or about 6.5 per cent. Economizers could be used with the all-steam units, but on account of the feed-water temperature, 208 deg. fahr., the saving would be only 4.1 per cent, making the B.t.u. per kilowatt-hour for this type of plant 18,540. The steam-electric plant, therefore, shows an improvement of 2.9 per cent. The investment cost per kilowatt, however, is increased from $65.00 to $70.31. Whether or not it would pay to use the steam-electric combination, viewing it from the point of view of cost of power only, would depend upon the load factor. Reliability, certainly, is not as good with the electric-driven units, as two additional links have been added to the auxiliary system. In the writer's opinion, electric-driven auxiliaries should never be used for boiler feed, and only with steam support for excitation.

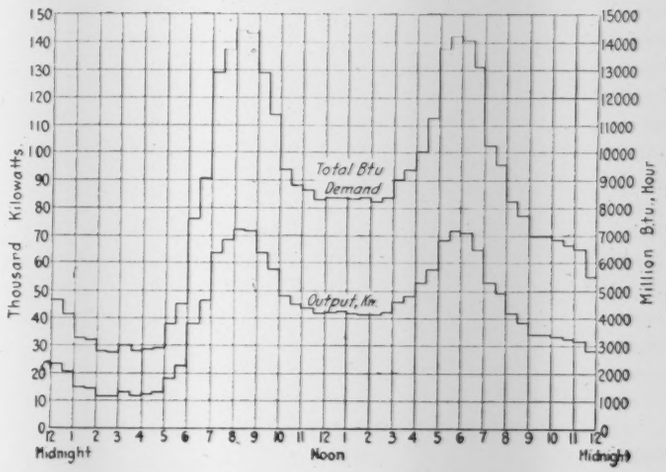


FIG. 14 ANTICIPATED LOAD CURVE AND HEAT INPUT, BALANCED

Another method is to use part steam and part electric

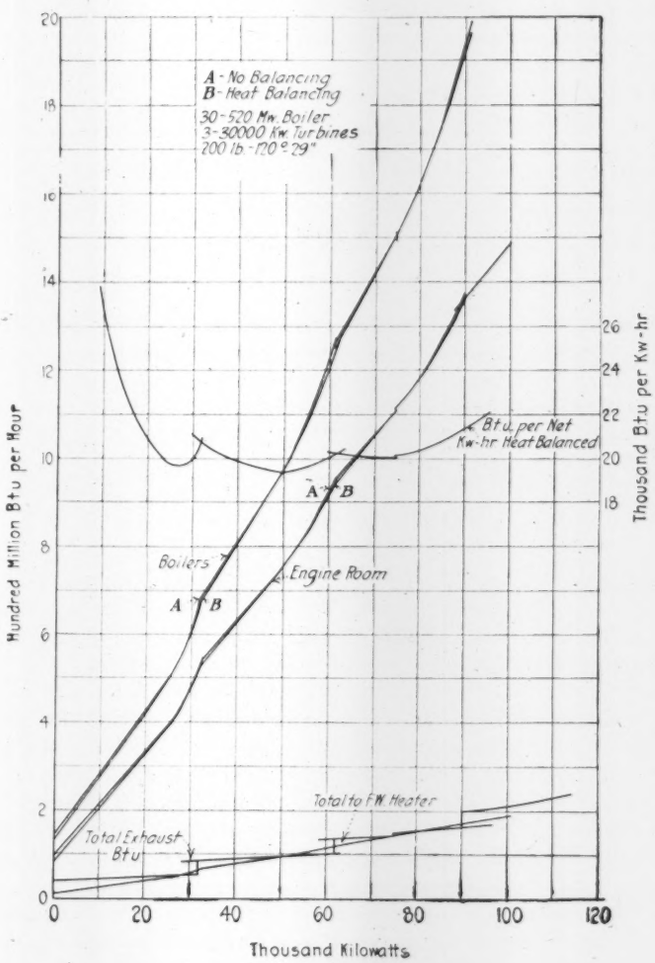


FIG. 13 PLANT INPUT-OUTPUT LINES

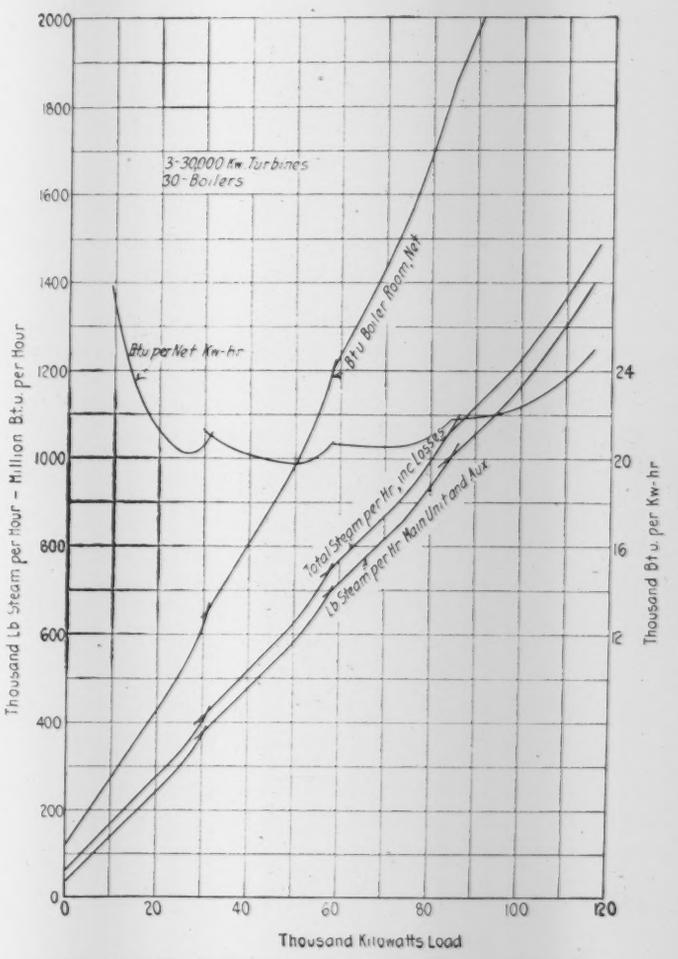

3-30,000 Kw. Turbines
30-Boilers
Thousand Lb Steam per Hour - Million B.t.u. per Hour
Thousand B.t.u. per Kw-hr
B.t.u. per Net Kw-hr
B.t.u. Boiler Room, Net
Total Steam per Hr., inc Losses
Lb Steam per Hr Main Units and Aux
Thousand Kilowatts Load

FIG. 15 PLANT INPUT-OUTPUT LINES, ALL-ELECTRIC AUXILIARIES

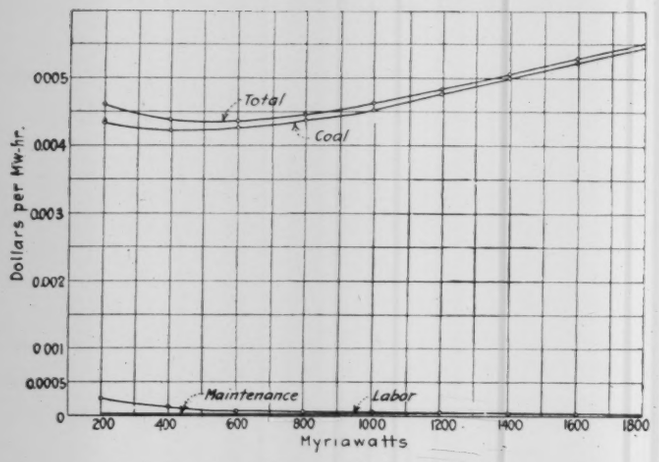


FIG. 16 COST OF OPERATION PER MYRIAWATT-HOUR, BOILERS

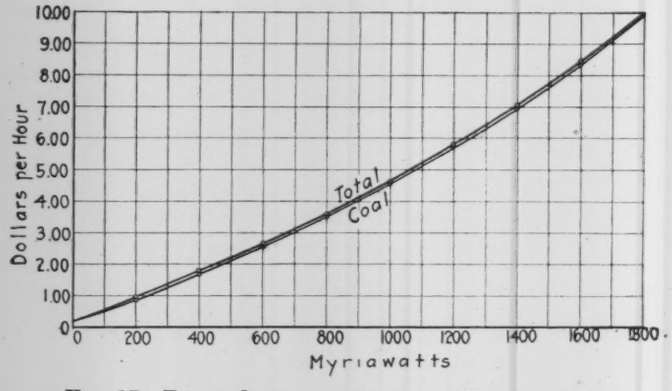


FIG. 17 TOTAL OPERATING COST PER HOUR, BOILERS

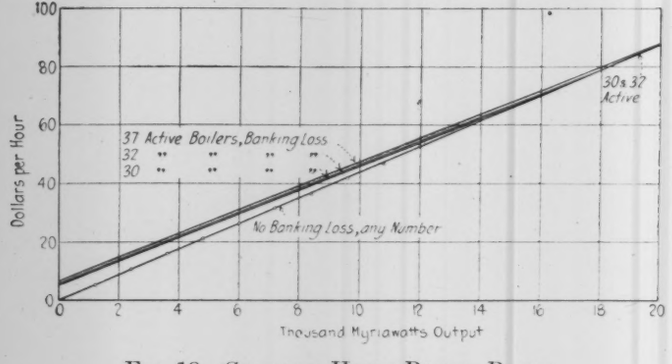

30 & 37 Active
37 Active Boilers, Banking Loss
32 " " " "
30 " " " "
No Banking Loss, any Number
Dollars per Hour
Thousand Myriawatts Output

FIG. 18 COST PER HOUR, BOILER PLANT

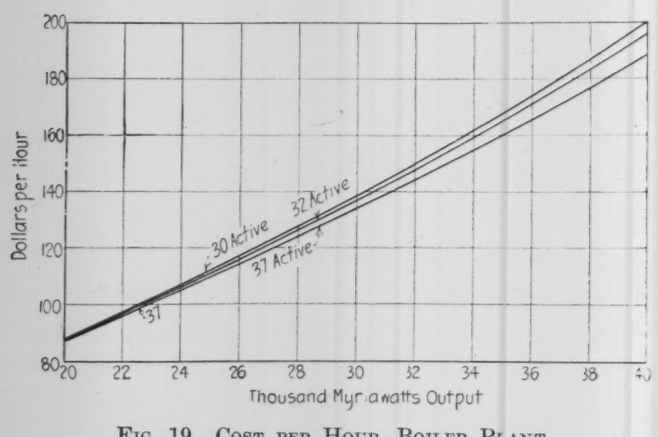


FIG. 19 COST PER HOUR, BOILER PLANT

auxiliaries, as is done in many plants, but the limits of this paper will not permit the analysis of all possible combinations. The above reasons show why the slightly more economical combination steam-electric auxiliary was not considered for the Interborough plant; reliability was paramount.

Number of boilers to install. The best number of boilers and stokers to install for a given load curve can be determined readily. The cost per myriawatt-hour to operate a boiler and stoker is given in Fig. 16. The curves are based

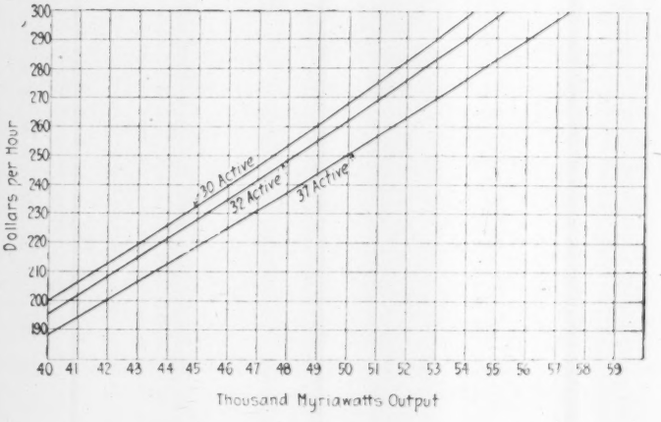


FIG. 20 COST PER HOUR, BOILER PLANT

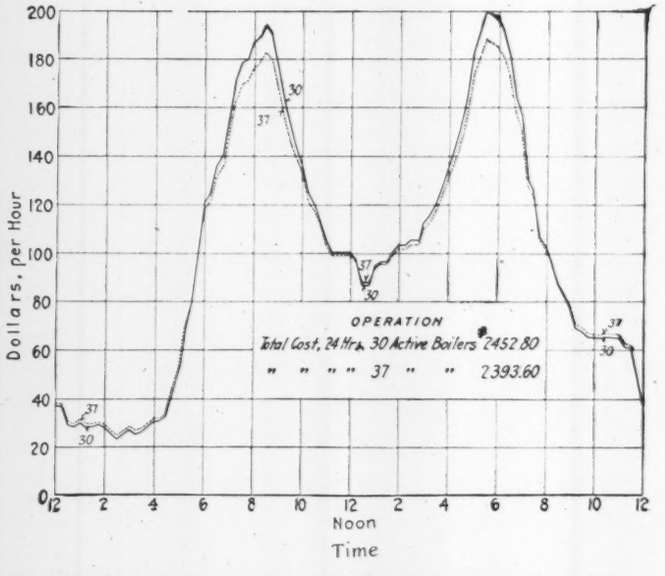


FIG. 21 HOURLY VARIATION OF BOILER-ROOM OPERATING COST, ANTICIPATED WINTER LOAD

on the following data: Coal at $0.103 per million B.t.u. ($3.30 per ton, heat value 14,250 per pound of dry coal), maintenance at $0.03 per ton of coal fired, labor, one operator at $0.40 per hour and one helper at $0.20 per hour for every twelve stokers. Fig. 17 shows the total operating cost per hour per myriawatt load, and the total cost of coal. The total cost plainly follows the heat input-output line. Figs. 18, 19 and 20 show the boiler-room cost lines in dollars per myriawatt-hour for different numbers of boilers in operation.

Using the total heat demand as before, but separately for different numbers of boilers, Fig. 21 is obtained. This shows 30 boilers more economical at light loads and 37 more economical at heavy loads, and for a typical day shows a net

saving of $59.20 by the large number of boilers. In a new plant, unquestionably the greater number of boilers would not pay, as the fixed charges more than offset the operating saving. The actual case in question required stokers and equipment, but not boilers, as these were already installed. The saving would not pay the fixed charges on the greater number of boilers even in this case. It is evident that the load factor is the controlling item.

CONCLUSION

For rapid estimates it is evident that the curves presented in this paper will give some useful relations for analyzing operating records. For instance, the engine-room steam demand with all-steam auxiliaries, in Fig. 13, balanced, might be represented with fair accuracy by the straight line $H = a + bL$,

where a = the no-load losses in the engine room = 60,000,000 B.t.u. per hr.

b = the intrinsic B.t.u. rate of the engine room = 14,000 B.t.u. per hr.

L = the kilowatt load on the plant

H = steam demand, B.t.u. per hour.

This average curve smooths out the humps in the original line. It is found, by investigating eight cases, that the total heat input-output amounts between 0.30 and 0.80 load factor will lie on the curve of total B.t.u. plotted from the above straight-line engine-room demand and by use of Fig. 9, for any load curve. Variations of peak load within 15 or 20 per cent are also found to agree. In short, the average heat consumption for any load curve can be taken from this chart as the amount corresponding to the average load without correction.

The writer has indicated only a few of the valuable features of the graphic method of analysis in steam power plants, which not only shorten the labor in power plant design, but reduce the chances of error and encourage a rigorous heat analysis. It is hoped that these curves will prove of value to others investigating similar problems.

THE FLOW OF AIR AND STEAM THROUGH ORIFICES

By HERBERT B. REYNOLDS, NEW YORK

Junior Member

THIS paper is in two parts, the first covering the flow of air through orifices, including a study of pitot and venturi tubes for measuring compressed air, and the second the flow of steam through orifices at low pressures. Both investigations were undertaken for the want of available data on these subjects under the particular conditions mentioned.

Thin-plate orifices were used in both the air and steam measurements. From the data of both the air and the steam tests empirical equations were derived for computing the flow. Both equations were proved out by checking computations for the quantities of air and steam passed against actual measurement of the quantities, and curves were plotted to show the close agreement between computed and test results.

In connection with the air-flow investigation the coefficients of two venturi tubes and one Taylor pitot tube were also experimentally worked out, as there are occasions where these means of measuring air flow are preferable to orifice measurement because they do not cause any drop in pressure.

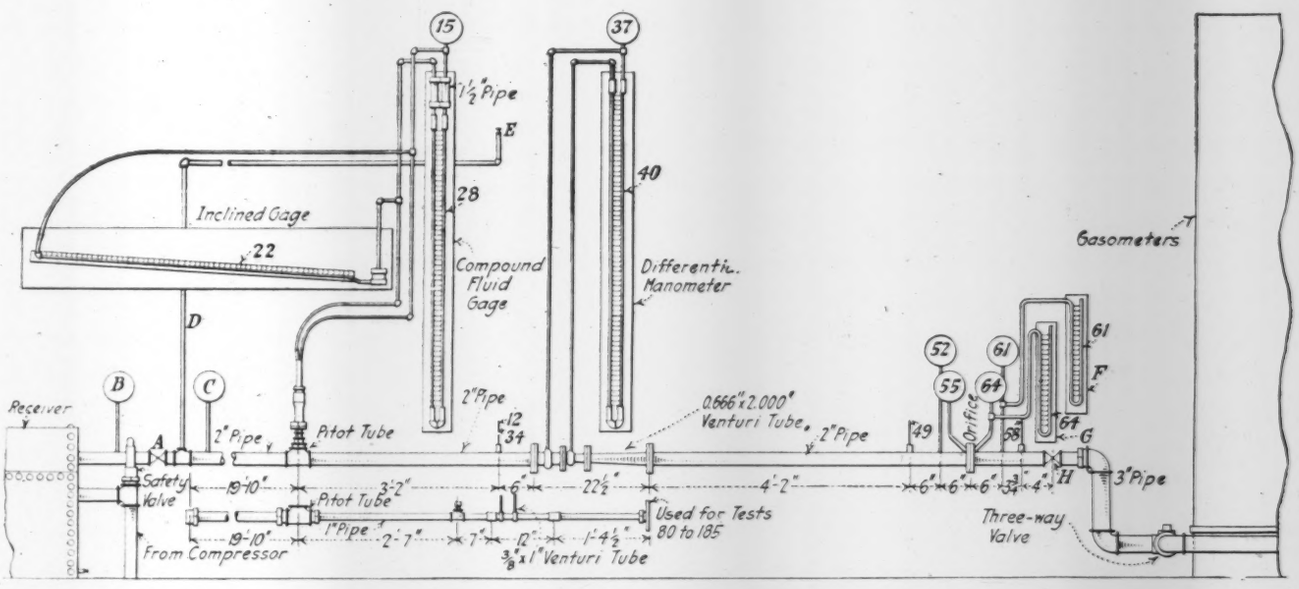


FIG. 1 LAYOUT OF APPARATUS FOR AIR TESTS

DESCRIPTION OF THE APPARATUS

The apparatus for the experiments was set up in the mechanical laboratories of Sibley College, Cornell University, in the Spring of 1913. The compressed air was furnished by a two-stage steam-driven compressor of about 150 cu. ft. capacity. A slight additional capacity was obtained by using a Westinghouse locomotive compressor. These two

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

compressors discharged into a common receiver of about 12 cu. ft. capacity.

The rest of the layout of the apparatus can be understood from Fig. 1. The air passed from the receiver through a 2-in. pipe line to a valve *A*, Fig. 1, that was used to regulate the pressure on the apparatus, a gage each side of it showing the pressures. To obtain a still closer adjustment of the pressure a small pipe was tapped into the line, *D*, Fig. 1, at the end of which a small valve *E* was attached.

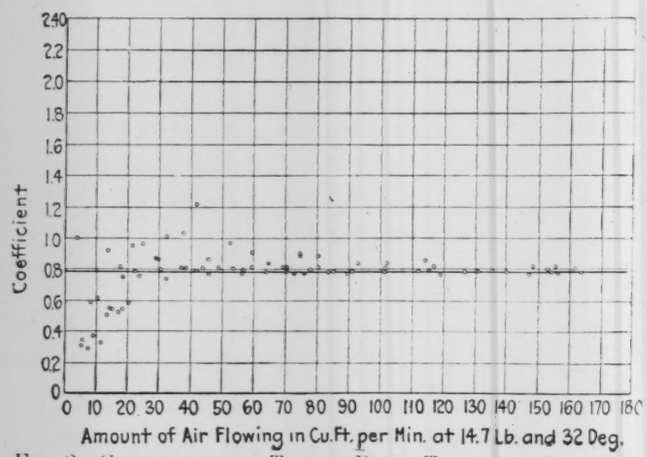


FIG. 2 COEFFICIENT OF TAYLOR PITOT TUBE IN A 2-IN. PIPE

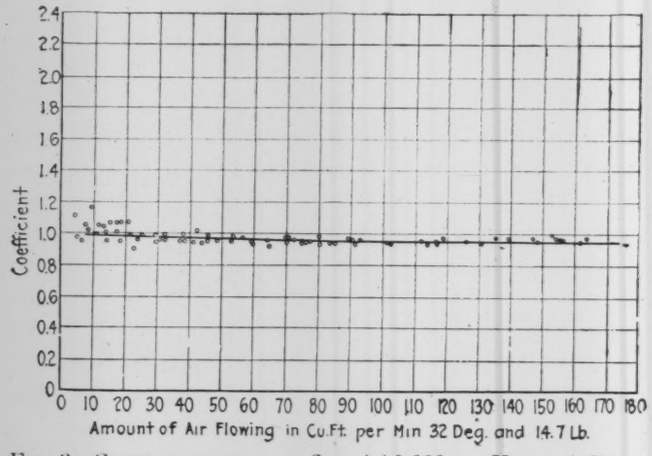


FIG. 3 COEFFICIENT OF THE 2-IN. × 0.666-IN. VENTURI TUBE

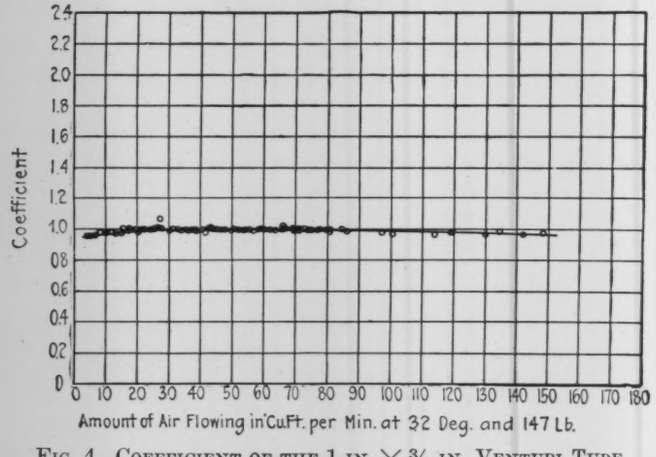


FIG. 4 COEFFICIENT OF THE 1-IN. × ⅜-IN. VENTURI TUBE

With the apparatus arranged for tests Nos. 1 to 79, the air, after passing the throttle valve *A*, flowed through a 2-in. pipe at the end of which a standard Taylor pitot tube was inserted through a pipe tee. The tube extended up into the pipe, so that the tee did not interfere with the motion of the air until after the pitot tube had been passed. The stem of the tube passed through a stuffing box which prevented leakage. This stuffing box also had a ball-and-socket joint, so that the tube could be adjusted in its position in the pipe line. With the stuffing box a traverse of the pipe could have been made, but as time did not permit, the tube was kept always in the center of the pipe.

To determine the velocity head from the pitot tube, two forms of manometers were used. One was the familiar form of compound fluid manometer with water as the heavier and olive oil as the lighter fluid. As constructed, and by using the above fluids, the readings were multiplied about ten times. In addition an inclined gage of the ordinary draft-reading type was used that could be set at different angles, to give any multiplier. In its lowest position the readings were multiplied about forty times.

After the air passed the pitot tube it flowed through a short 2-in. pipe and then through a venturi tube. Just before the air passed into the venturi tube its temperature was taken by a thermometer in a well tapped into the pipe. An ordinary differential manometer determined the difference of pressure between the mouth and throat of the venturi tube. A pressure gage was attached, as shown, from which the total pressure of the air at the mouth was obtained.

After flowing through the venturi tube, the air continued through a 2-in. pipe and then through a square-cornered orifice in a thin plate inserted in the line between two standard pipe flanges. The pressure was obtained on each side of the orifice in two places. One gage was tapped into the side of the pipe 6 in. from the orifice, while the other gage was tapped into the flange on an angle, so that the pressure was obtained right at the face of the orifice. Different orifices were used during the tests, which were made by drilling a brass plate and not rounding the corners except to remove the burr formed by the drilling. After leaving the orifice the air passed through the valve *H*, which was used for adjusting the final pressure.

Thence, the air flowed through a 3-in. pipe to a three-way cock, by which it could be discharged into either of two gasometer tanks, each of about 100 cu. ft. volume. Thus an absolute measure of the volume of air flowing was obtained, the rise of each tank being determined by a scale reading to tenths of inches. The pressure of the air in the tanks, which varied from 2 to 4 in. of water, was obtained from a water manometer on top of each tank. The air temperature in the gasometer tanks was determined by thermometers inserted through their tops.

As the tests were very short and the air in the tanks was kept in motion by the inflowing air, it is believed that representative temperature readings were obtained. Through large quick-opening valves on top of the tanks they were emptied after the readings were taken.

The arrangement of the apparatus for tests Nos. 80 to 185 was somewhat different. After passing through the throttle valve *A* the air passed through a 1½-in. pipe and then past the same Taylor pitot tube as in the first tests. This time the pitot tube was in the center of the 1½-in. pipe. The same manometers were used as before for obtaining the velocity head. Beyond the pitot tube the air passed a thermometer registering its temperature, and then through a 1 × ⅜-in. venturi tube. This tube is in one piece and

not of exactly the same form as the larger tube used before. From this point on, the layout of the apparatus was the same as for the other tests.

DESCRIPTION OF THE TESTS

A leakage test was run on each tank to determine the necessary correction for leakage. The actual volume of each gasometer was computed from the average diameter found by measuring the diameter of the inside tank at a great many points (four diameters at every foot throughout the length).

The compound fluid manometer and the inclined manometer used in connection with the pitot tube were calibrated by connecting to a U-tube manometer, and taking readings at several points. All pressure gages were calibrated by a dead-weight gage tester. All thermometers were calibrated by reference to a standard thermometer.

The tests were run as follows: An orifice was selected and placed in the line; both gasometer tanks were emptied, the exhaust valve on one tank was left open while that on the other was closed, the three-way valve was then turned so that the air could enter the gasometer that was open to the atmosphere; the throttle valve *A*, Fig. 1, was then opened until the gage *C* indicated a pressure slightly in excess of that desired; the pressure was then adjusted by the valve *E* and gage 37; then the three-way valve was quickly turned so that the air discharged into the gasometer that was closed. When this gasometer was full the three-way valve was turned back to its original position so that the air flowed into the other gasometer, which in the meantime had been closed.

The rise of the first tank and the pressure and temperature of the air in it were then recorded while the second tank was filling. After the readings had been taken the exhaust valve was opened allowing the tank to empty. After a length of time equal to that taken to fill the first gasometer, the three-way valve was quickly turned, so that the air could flow to the atmosphere through the first gasometer. The rise, temperature, and pressure were then recorded for the second gasometer. The pressure in the pipe line was maintained constant during the entire operation. The various gages and thermometers along the pipe line were read every 5 min. during the long tests, and as often as possible during the short tests.

Tests were made on each orifice at pressures of 10, 15, 20, 30, etc., up to 100 lb. per sq. in. gage. During most of the tests the final pressure on the discharge side of the orifice was kept constant at 14.7 lb. per sq. in. abs. However, a few tests were run with final pressures as high as 90 lb. per sq. in. gage. If during any test the rise of the two gasometer tanks did not check each other within one inch, the test was repeated.

To test the pitot and venturi tubes for large volumes and low pressures, a few tests were run without any orifice in the line. The flow during these tests was adjusted by the back-pressure valve *H*.

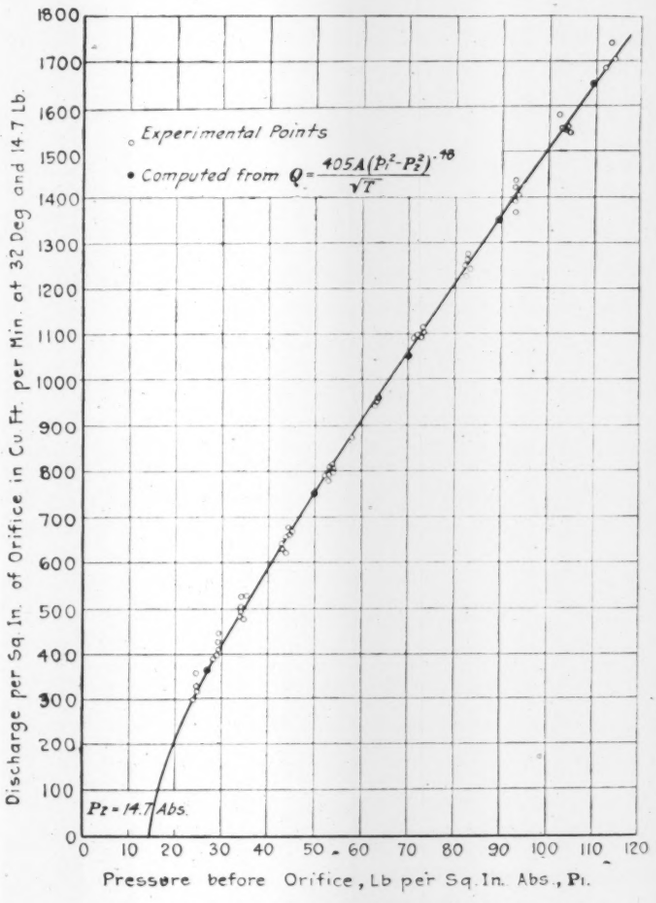

Experimental Points
Computed from $Q=\frac{405A(P_1^2-P_2^2)^{.46}}{\sqrt{T}}$
P_2 = 14.7 Abs.
Discharge per Sq In. of Orifice in Cu Ft. per Min at 32 Deg and 14.7 Lb.
Pressure before Orifice, Lb per Sq In. Abs., P_1.

FIG. 5 INITIAL PRESSURE-QUANTITY CURVE. FINAL PRESSURE = 14.7 LB.

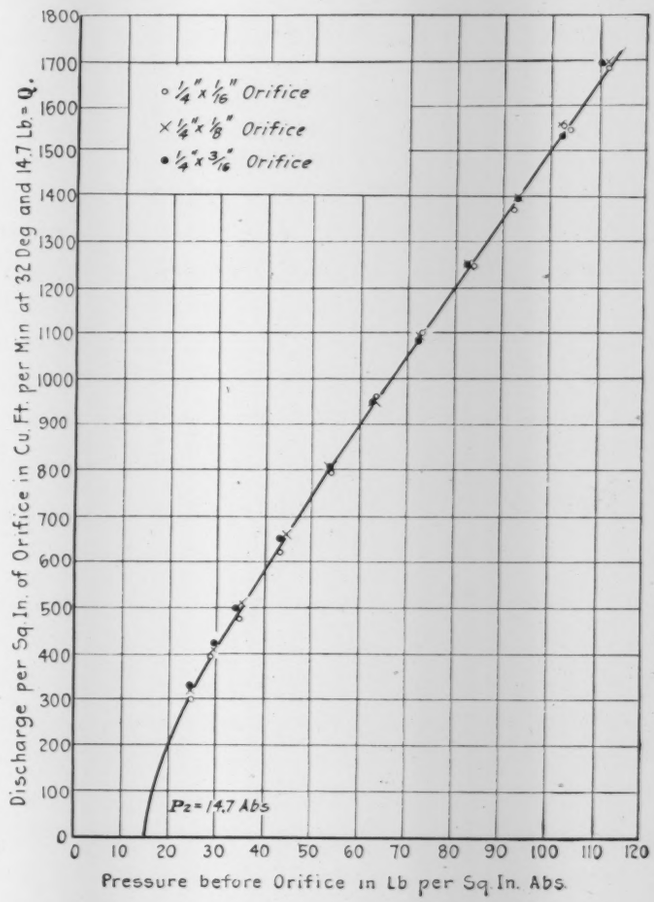

1/4" x 1/16" Orifice
1/4" x 1/8" Orifice
1/4" x 3/16" Orifice
P_2 = 14.7 Abs.
Discharge per Sq In. of Orifice in Cu Ft. per Min at 32 Deg and 14.7 Lb. = Q.
Pressure before Orifice in Lb per Sq In. Abs.

FIG. 6 INITIAL PRESSURE-QUANTITY CURVE. ORIFICES OF DIFFERENT THICKNESSES

During most of the tests, water was the fluid used in the venturi manometer, but, during some the readings were so high that it was necessary to use mercury.

COMPUTATIONS

All of the computations are simple and need no explanation. However, the equations used for the pitot tube, venturi tube, and the orifice will be given.

The equation for the pitot tube was taken from a paper by Thomas R. Weymouth on the Measurement of Natural Gas.[1]

$$V = \sqrt{\frac{2\,gh\delta w\,14.7\,T}{12\,\delta a\,492\,PG}}$$

where V = velocity of flowing gas, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec.
h = velocity head, in. of water.
δw = weight of water, lb. per cu. ft.
T = absolute temperance of flowing gas, deg. fahr.
δa = weight of 1 cu. ft. of air at 32 deg. fahr. and 14.7 lb. per sq. in. abs. = 0.08073 lb.
P = absolute pressure of flowing gas, lb. per sq. in.
G = specific gravity of flowing gas, air = 1.000.

The equation which was used for the venturi was taken from the same paper by Weymouth and is as follows:

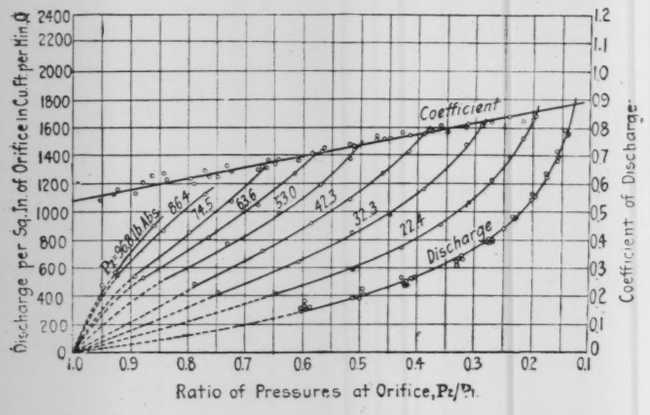


FIG. 7 COEFFICIENT OF DISCHARGE FOR ORIFICES IN 1/16-IN. PLATE

$$Q = \frac{3514\,A_2T_s}{P_s}\sqrt{\frac{n}{(n-1)\,G}}\,\frac{P_1}{\sqrt{T_1}}\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}\sqrt{\frac{1-\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}}{1-\left(\frac{A_2}{A_1}\right)^2\left(\frac{P_2}{P_1}\right)^{\frac{2}{n}}}}$$

where Q = quantity of air per minute at 32 deg. and 14.7 lb. abs., cu. ft.
A_2 = area of throat, sq. ft.
A_1 = area of entrance, sq. ft.
T_s = absolute temperance of standard air = 492 deg. fahr.
P_s = absolute pressure of standard air = 14.7 lb, per sq. in.
n = a constant, for air = 1.402.
G = specific gravity of gas, air = 1.000.
P_1 = pressure of air at entrance, lb. per sq. in. abs.
P_2 = pressure of air in throat, lb. per sq. in. abs.
T_1 = temperature of air at entrance, deg. fahr. abs.

The equation which was used for the orifice was taken from Hirshfeld and Barnard's Elements of Heat Power Engineering, and is as follows:

$$Q = \frac{1522\,P_1A}{\sqrt{T_1}}\sqrt{\left(\frac{P_2}{P_1}\right)^{1.42} - \left(\frac{P_2}{P_1}\right)^{1.71}}$$

where Q = quantity of air per minute at 32 deg. and 14.7 lb. abs., cu. ft.
P_1 = initial pressure, lb. per sq. in. abs.
P_2 = final pressure, lb. per sq. in. abs.

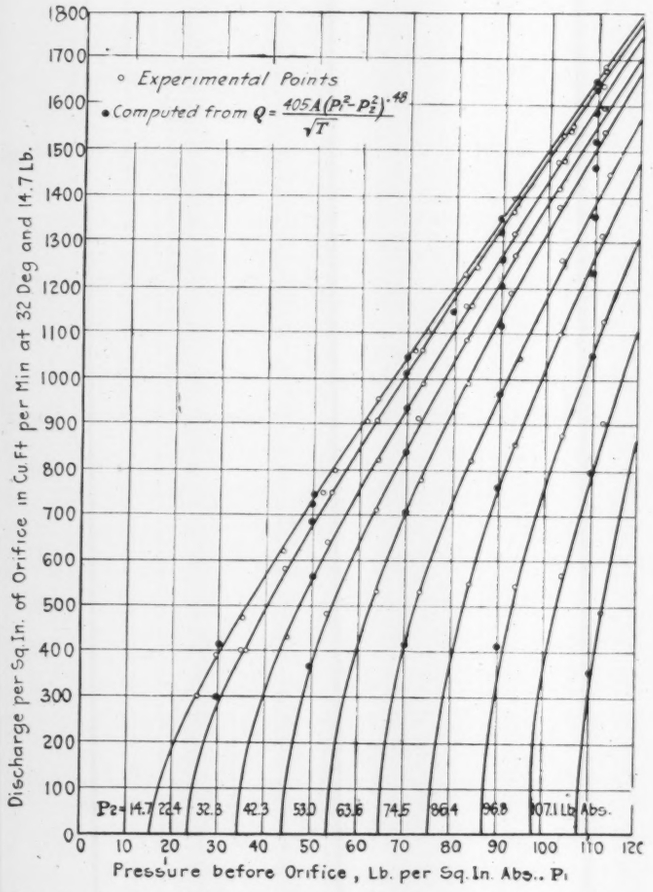

Experimental Points
Computed from Q = 405 A (P1² - P2²) .48 / √T
Discharge per Sq. In. of Orifice in Cu Ft per Min at 32 Deg and 14.7 Lb.
Pressure before Orifice, Lb. per Sq. In. Abs., P1
P2= 14.7 22.4 32.3 42.3 53.0 63.6 74.5 86.4 96.8 107.1 Lb. Abs.

FIG. 8 INITIAL PRESSURE-QUANTITY CURVES. VARIOUS FINAL PRESSURES

A = area of orifice, sq. in.
T_1 = initial temperature of air, deg. fahr. abs.

Using the foregoing three theoretical equations, coefficients were computed for the pitot tube, venturi tube, and the orifices. The actual volume of the air flowing during the tests was computed from the known dimensions of the gasometers. Corrections were made for temperature, pressure, leakage, zero reading of scale, etc.

PITOT AND VENTURI TUBES

Fig. 2 gives a curve of coefficients for the Taylor pitot tube when in the center of a 2-in. pipe. The coefficients were computed using the readings from the inclined gage, as it was impossible to obtain satisfactory readings from the compound fluid gage. This figure shows that the pitot tube is uncertain when used in a 2-in. pipe if the amount of air flowing is less than 40 or 50 cu. ft. per min. while the coefficient becomes fairly steady when the discharge is greater than 80 cu. ft. per min.

[1] Trans. Am.Soc.M.E., vol. 34, p. 1639.

A similar curve, not shown, was plotted of coefficients for the same tube when in the center of a 1½-in. pipe, the velocity head being obtained with the inclined gage as before. This curve showed that below 30 cu. ft. per min. the results are not very reliable and that the coefficient increases with increase in velocity until at about 90 cu. ft. per min., after which it is constant.

The curve in Fig. 3 of coefficients for the 2 × 0.666-in. venturi tube, shows that the average is about 0.95. It also shows that this size of venturi tube is not accurate when the flow is less than 25 cu. ft. of free air per minute, and that the coefficient decreases slightly as the flow increases.

The curve of coefficients for the 1 × ⅜-in. venturi tube is shown in Fig. 4. This curve differs slightly from that for the larger tube, and the average coefficient is higher, being about 0.99 over most of the range of the tests. The reason for this difference in the curves, and the coefficients is that the converging section of the larger tube continues up to where the throat pressure is taken. This tends to contract the stream at the throat, and so to give a lower pressure reading here than should be. This causes the reading to be high. In the smaller tube the converging section stops before the point where the pressure is taken so that the stream completely fills the throat at that point. The contraction effect is greater at the high velocities which explains the decrease in the coefficient at the high rates of flow.

As has been mentioned the pressure was taken near the orifice at two points. However, it was impossible to detect any difference between the pressures taken at these two points with the gages used, which could be read to the nearest pound, the smallest division on the scale being 5 lb.

It was impossible to keep the temperature of the air constant during the tests, so the actual discharge has been corrected to 32 deg. fahr. by multiplying the actual discharge by the factor $\sqrt{\frac{T}{492}}$, in which T is the absolute temperature of the air flowing.

Judging from the results the size of the orifice has no effect upon the coefficient of discharge.

The open circles in Fig. 5 are the experimental points obtained from all the orifices in the 1-16-in. plates. The solid circles will be mentioned later.

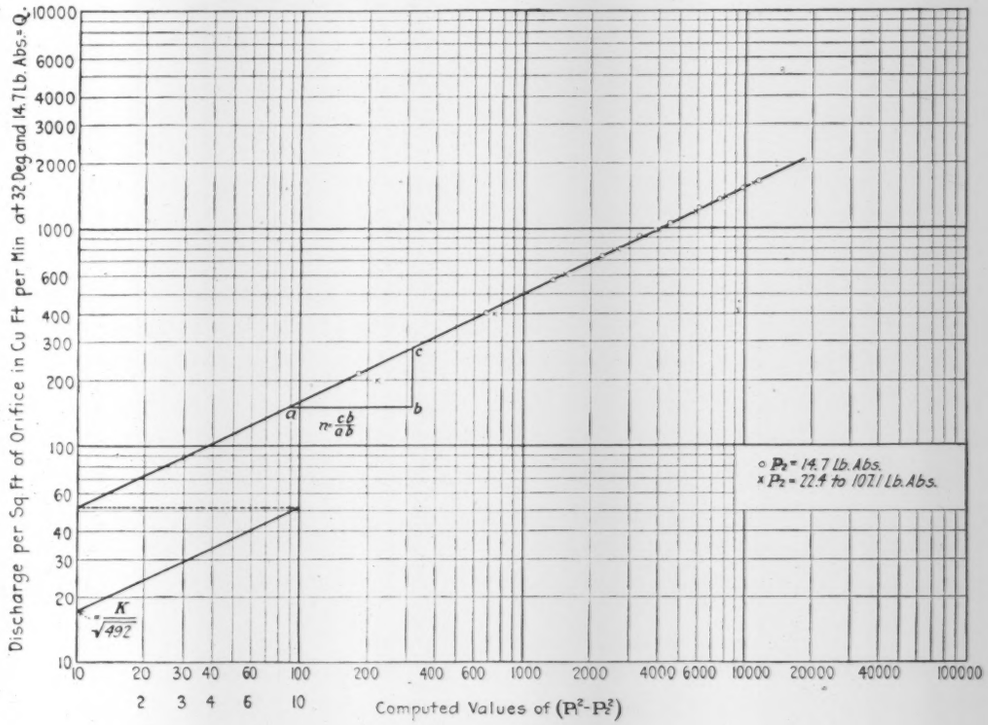


FIG. 9 QUANTITY-$(P_1^2 - P_2^2)$ CURVES

To compare orifices of the same size but in different thicknesses of plate, tests were run on three orifices ¼-in. diameter. The first was in 1-16-in. plate, the second in ⅛-in. plate, and the third was in 3-16-in. plate. The curve and points in Fig. 6 show that very nearly the same result was obtained in each case.

Fig. 7 shows how the coefficient of discharge and the actual discharge vary with the ratio of pressure at the orifice, when the final pressure is constant at 14.7 lb. per sq. in. abs.

A number of tests were run on the ¼ × 1-16-in. orifice with various back pressures from atmospheric pressure up to about ninety pounds gage. The results of these tests are shown in Fig. 8.

Fig. 7 also shows the coefficient of discharge and the discharge plotted against the ratio of pressures at the orifice, for the tests when the final pressure was greater than atmospheric pressure.

ORIFICES

A number of tests were run on various-sized orifices from ⅛ to ½-in. increasing in size by 1-16 in. These orifices were all formed in 1-16-in. brass plate. The actual results of these tests are shown in Fig. 5.

FLOW OF AIR THROUGH A THIN-PLATE ORIFICE

For a given orifice the flow of air involves three variables—the quantity discharged, the initial pressure, and the final pressure. Evidently then the geometric figure that illustrates the relation of the three variables, is a curved surface involving all three dimensions. Examination of the various curves discussed above shows them to be conic sections. The equation of a cone whose axis coincides with the z axis, is:

$$m^2 (x^2 + y^2) = (z - c)^2$$

where m is the slope of the surface of the cone with the z axis and c is the intercept on the z axis. For a special case when the apex of the cone is at the origin, $c = 0$, and when the surface of the cone is at an angle of 45 deg. with the axis, $m = 1$. In our case $c = 0$, $m = 1$, $x = P_2$, $y = Q$, and $z = P_1$; then, by substitution:

$$Q^2 = K'(P_1^2 - P_2^2)$$

or the general form of the equation is,

$$Q = \frac{KA\ (P_1^2 - P_2^2)^n}{\sqrt{T}}$$

To obtain the numerical values of K and n, values of $(P_1^2 - P_2^2)$ were computed from the results of the tests and plotted against the quantity Q in Fig. 9. From this logarithmic curve it was found that $K = 405$ and $n = 0.48$. Thus the final equation is,

$$Q = \frac{405\ A\ (P_1^2 - P_2^2)^{0.48}}{\sqrt{T}}$$

where Q = quantity of air discharged per min. at 32 deg. fahr. and 14.7 lb. per sq. in. abs., cu. ft.
A = area of the orifice, sq. in.
P_1 = initial pressure before orifice, lb. per sq. in. abs.
P_2 = final pressure after orifice, lb. per sq. in. abs.
T = absolute temperature of air entering orifice, deg. fahr.

To check the accuracy of this equation, values were computed for various pressures. These are plotted in Figs. 5 and 8 and are shown by the solid circles. It will be seen that these points coincide closely with the experimental curves.

TYPICAL RESULTS SELECTED FROM TESTS ON THE TAYLOR PITOT TUBE IN A 2-IN. PIPE

No.	General Data				Pitot Tube				
	Barometer, in. Hg at 32 deg. fahr.	Length of test in minutes	Cu. ft. of air per min. at 32 deg., 14.7 lb. abs.	Temp. of room, deg. fahr.	Temp. of air, deg. fahr.	Pres. of air, lb. abs.	Actual velocity in pipe, ft. sec.	Velocity head, in. water	Coefficient of tube
12	29.44	20.00	8.6	65	64.4	25.4	3.82	0.017	0.584
13	29.44	16.00	10.9	66	65.1	29.9	4.12	0.021	0.608
14	29.47	12.00	14.0	70	69.9	35.4	4.48	0.013	0.923
15	29.47	10.00	17.8	70	70.0	45.4	4.48	0.021	0.818
16	29.47	8.00	21.5	70	70.6	54.8	4.49	0.018	0.957
17	29.44	6.00	25.3	70	70.7	64.5	4.49	0.021	0.963
18	29.44	6.00	29.1	70	71.5	74.4	4.48	0.030	0.868
19	29.44	5.92	32.5	71	73.2	84.4	4.44	0.024	1.018
20	29.44	4.00	38.0	57	56.7	94.4	4.47	0.028	1.037
21	29.44	4.00	42.1	59	58.1	103.4	4.55	0.022	1.225
22	29.44	4.00	45.7	60	61.1	114.1	4.51	0.060	0.775

TYPICAL RESULTS SELECTED FROM TESTS ON 2-IN. BY 0.666-IN. VENTURI TUBE

No.	Temp. of air, deg. fahr.	Pres. of air, lb. abs.	Difference of pres. between mouth and throat, lb.	Ratio of pres. at mouth and throat	Cu. ft. of air per min. at 32 deg., 14.7 lb., computed	Coefficient of tube
12	64.4	24.42	0.01980	0.99919	8.4	1.017
13	65.1	29.52	0.02670	0.99909	10.9	0.999
14	69.9	34.73	0.03680	0.99894	13.9	1.009
15	70.0	44.43	0.04690	0.99894	17.7	1.002
16	70.6	54.43	0.0567	0.99895	21.6	0.997
17	70.7	64.22	0.0664	0.99896	25.5	0.993
18	71.5	73.92	0.0761	0.99897	29.2	0.998
19	73.2	83.82	0.0867	0.99897	33.0	0.986
20	56.7	94.12	0.0978	0.99896	38.0	0.998
21	58.1	104.22	0.1118	0.99893	42.6	1.011
22	61.0	114.13	0.1230	0.99892	46.6	0.982

TYPICAL RESULTS SELECTED FROM TESTS ON AIR ORIFICES

No.	Size of orifice, inches	Temp. of air entering orifice, deg. fahr.	Initial pres. of air, lb. abs.	Final pres. of air, lb. abs.	Ratio of pres. at orifice	Actual discharge per sq. in. of orifice, cu. ft. per min. at 32 deg. and 14.7 lb.	Coefficient of discharge	Discharge per sq. in. of orifice, corrected to 32 deg. fahr.
12	3/16 by 1/16	64.3	24.7	14.7	0.598	311	0.713	321
13	3/16 by 1/16	65.0	29.5	14.6	0.498	394	0.774	426
14	3/16 by 1/16	69.3	36.0	14.6	0.411	507	0.822	526
15	3/16 by 1/16	69.7	45.4	14.6	0.322	644	0.820	668
16	3/16 by 1/16	70.1	54.4	14.6	0.268	778	0.826	807
17	3/16 by 1/16	70.3	63.9	14.6	0.230	916	0.834	951
18	3/16 by 1/16	71.0	73.9	14.6	0.199	1052	0.830	1092
19	3/16 by 1/16	73.0	82.9	14.6	0.176	1178	0.827	1227
20	3/16 by 1/16	57.0	93.9	14.6	0.155	1373	0.830	1408
21	3/16 by 1/16	58.0	104.7	14.6	0.139	1522	0.829	1559
22	3/16 by 1/16	60.4	114.0	14.6	0.127	1658	0.830	1704

POWER-PLANT EFFICIENCY

By VICTOR J. AZBE, ST. LOUIS, MO.

Junior Member

THIS paper will deal not so much with the efficiency available in an up-to-date power plant, as with the improvement possible in the thousands of plants that supply power for small factories, office buildings, and various institutions, since these are by far the most prevalent and, also, the most uneconomical.

In 1915 about six hundred million tons of coal were mined in the United States, and this enormous amount is steadily increasing. Suppose the average cost of coal delivered at the power plant is $1.80 per ton, then the total cost will be $1,080,000,000. In the ordinary power plant, conditions as shown in Fig. 1 exist, where the shaded areas (excluding the one marked "Indicated Energy") represent the preventable losses, aggregating about 30 per cent. Of our total expenditure for coal this is $324,000,000 each year, to say nothing of the natural gas and crude oil produced, burned and wasted, also without the cost of handling and firing, and investment in unnecessary boilers, machinery and labor. If everything could be computed, the total loss would exceed half a billion dollars and all due to *inefficiency of man*, which can be subdivided into:

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

a Lack of foresight and business ability
b Improper design
c Improper management and inefficient operation.

Often when a power-plant installation is planned, the owner fails to consult a competent designing engineer; ill advice from incompetent persons, prejudice and fear of investing needless money do the rest. The owner is not an engineer and cannot be expected to know where a greater initial expenditure for more economical power-generating equipment will pay. Therefore, every power-plant owner should have a consulting engineer, proficient in economical power-plant design and operation, and every such consulting engineer should have a staff of specialists capable of examining power plants in regard to their proper up-keep and operation and of instructing the operating force thereupon. Every plant should be examined at regular intervals, and the cost of such examination will be amply rewarded by the savings due to greater efficiency.

Owners are as much in need of education in power-plant economics as their employees. They should be impressed with these possibilities:

a From 10 to 30 per cent fuel-consumption reduction without additional investment, simply by more efficient operation
b Up to three times the amount of power from the same amount of fuel by installing proper equipment
c Investments can be made in a power plant bringing from 10 to 100 per cent in interest
d To obtain the above, specialists on economical power-plant operation and design should be consulted.

VALUE OF INSTRUMENTS

Instruments to show whether a plant is operated efficiently are generally wanting. In boiler rooms from 10 to 20 per cent of the fuel, and more in some of them, is wasted chiefly from lack of indicating devices to detect losses. Every boiler should have a draft gage and if possible a steam-flow meter. No boiler room should be without some form of gas-analysis instrument and flue-gas thermometer or pyrometer. Too much guessing is done in the average power plant, which is, in part, responsible for the miserable results obtained. Few plants pay particular attention to obtaining economic combustion; many operators have no idea what high CO_2, low CO, and other such expressions mean. Hence it is not surprising that there are boilers operated at 40 per cent efficiency.

An automatic CO_2 recorder has a great moral effect upon the fireman, and numerous boiler plants can thank this apparatus for a large saving in fuel consumption. The steam-flow meter on each boiler in connection with proper interpretation of the pressure drops through boiler gas passages, is also of great value and, with intelligent, trained men in charge, even preferred to the CO_2 recorder.

The common differential draft gage is also important, for, when properly connected, it will tell whether the boiler is being operated at, below, or above rating; and whether the fuel bed is too thick, or dirty, or full of air holes. But the draft readings must be intelligently interpreted and they seldom are. Few operating engineers know the real value of the draft gage.

REDUCIBLE LOSSES

The greatest and most neglected loss in the average boiler plant is from excess air. The curves, Fig. 2, show the magnitude of this loss at different CO_2 percentages and are applicable to any fuel, liquid, solid, or gaseous, if its available hydrogen percentage is known.

The impression prevails that coal must be burned with about 50 per cent. of excess air. Some authorities claim that going beyond 10 to 12 per cent CO_2 the loss due to incomplete combustion will offset the saving effected by reducing the excess air. This opinion is based upon certain types of installation only, and should not be accepted and disseminated as a general condition. Some few up-to-date plants are averaging 17 per cent CO_2 with bituminous coal, without serious losses due to incomplete combustion. The author himself obtained an analysis giving CO_2, 17.2 per cent; O, 1 per cent; CO, 0.1 per cent, which appears remarkable with bituminous coal, but is easily possible if the furnace construction is right. Hence it is ridiculous to use 200 per cent excess air as is often done; also 50 per cent is more than is needed, and with proper furnace design not more than 10 per cent excess air is required.

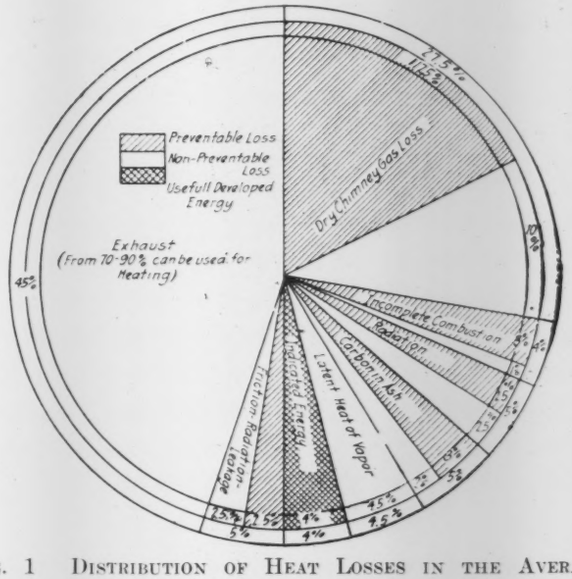


FIG. 1 DISTRIBUTION OF HEAT LOSSES IN THE AVERAGE POWER PLANT OPERATING NON-CONDENSING

With low percentages of excess air, proper design of combustion space becomes much more important, to prevent incomplete combustion and too high furnace temperatures. Exceedingly high furnace temperatures have no real advantage and several disadvantages, therefore heating surface exposed directly to the fuel bed to reduce the furnace temperature will not only cause a decrease of the slagging effect upon the fire brick, and thus increase the CO_2 possible to maintain, but will also increase the efficiency of the boiler due to the heat radiated directly to it, and will increase the boiler capacity without increasing the flue-gas temperature.

Fig. 3 shows the flue-gas temperatures with different well-known installations at various boiler ratings. It shows that results obtained are very varied, and that some installations obtain the same final temperature at 300 per cent of rating as others at 100 per cent. In one case at 200 per cent of rating, the temperature of the escaping gases was 285 deg. higher than in another, and this in spite of the fact that in both cases the amount of air used to generate 10,000 B.t.u. was the same. The seriousness of this will be realized from the fact that this condition causes a loss of about 11 per cent in fuel consumption to the high-temperature plant. This is at 100 per cent overload; at higher ratings this difference will increase as indicated by the curves.

Boilers can be operated at two times the rating, and more, but not economically unless designed for it; with the rates of heat absorption obtained at present in most installations, if operated at very high ratings the loss will be too great, unless the temperature of the escaping gases be reduced in economizers. The increase of velocity will cause draft loss, but this is not so serious, for the necessity of installing mechanical draft brings about advantages.

The author has found reduction of flue-gas temperature possible in most boiler installations by reducing excess air, increasing velocity, eliminating dead-gas spaces, re-baffling or installing auxiliary baffles, exposing some of the heating surface to direct radiation from the fuel bed, and last, but not least, maintaining clean heating surfaces by blowing with steam at regular intervals and scraping the heating surfaces when the boiler is down for cleaning.

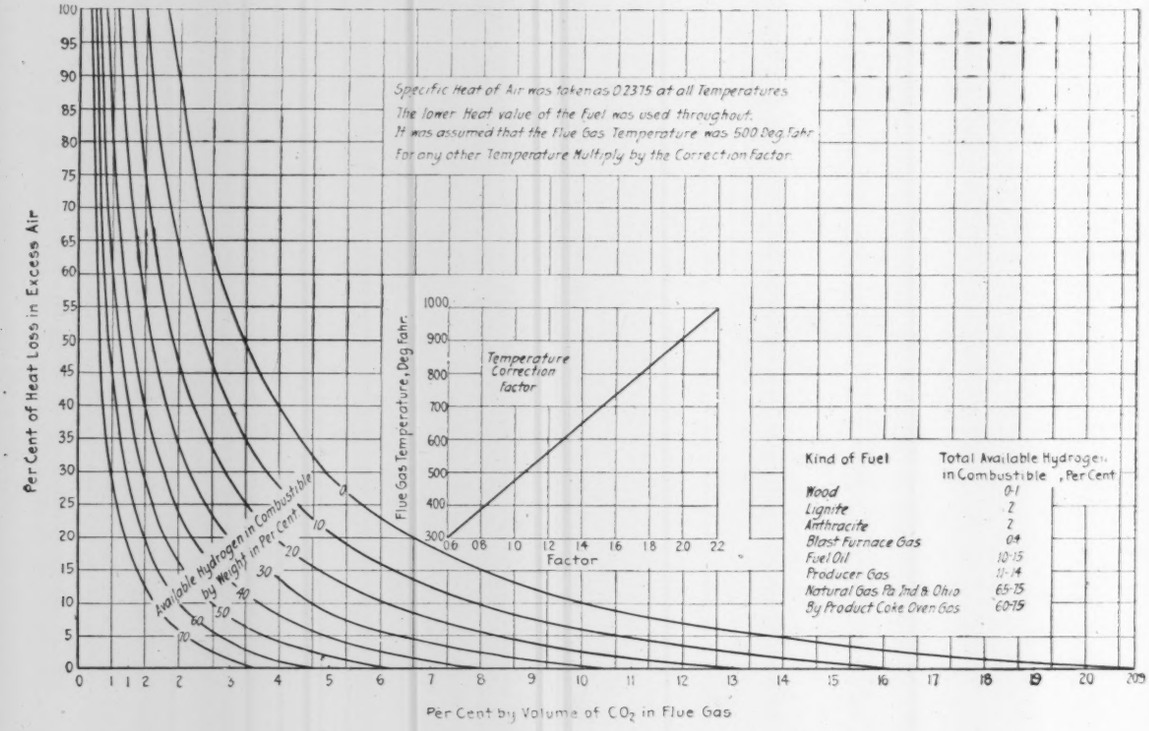

Specific Heat of Air was taken as 0.2375 at all Temperatures
The lower Heat value of the Fuel was used throughout.
It was assumed that the Flue Gas Temperature was 500 Deg. Fahr.
For any other Temperature Multiply by the Correction Factor
Per Cent of Heat Loss in Excess Air
Per Cent by Volume of CO_2 in Flue Gas
Available Hydrogen in Combustible by Weight in Per Cent
Flue Gas Temperature, Deg. Fahr.
Temperature Correction Factor
Factor
Kind of Fuel
Total Available Hydrogen in Combustible, Per Cent
Wood 0-1
Lignite 2
Anthracite 2
Blast Furnace Gas 0-1
Fuel Oil 10-15
Producer Gas 11-14
Natural Gas, Pa. Ind. & Ohio 65-75
By Product Coke Oven Gas 60-75

FIG. 2 HEAT LOSS FROM EXCESS AIR WITH FUELS OF DIFFERENT HYDROGEN CONTENT

ADVANTAGES OF ECONOMIZERS

Boiler-plant efficiency can be considerably increased by adding economizers. The objections ordinarily offered are:

a Their initial cost
b Reduction of available draft and, in many plants, necessity of installing mechanical-draft systems
c Cheap fuel (speaking comparatively)
d Low load factors
e Complication of the power-plant outlay.

The chief reason that they are not used more generally is that their value is not realized. They are particularly needed in plants having variable loads. Much depends upon properly proportioning the installation and, therefore, before an economizer is decided upon, a plant must be closely studied and the governing factors, such as flue-gas temperature, feed-water temperature, weight of air per pound of coal, load factor, character of load, etc., very closely predetermined.

Economizers do considerably reduce the draft, but often much of the total loss is the fault of the gas passages from the boiler to the economizer and from them to the stack. With natural draft, there will be additional reduction of available draft resulting from the reduction of the stack temperature. The loss of draft because of economizers is partly offset by the higher efficiency and therefore smaller amount of coal burned, and also by the ability to operate more economically the auxiliaries that previously exhausted into a feed-water heater, which, saving steam, will somewhat reduce the amount of coal burned and, consequently, also the draft required. Maintaining high CO_2 percentage, together with having tight breeching, clean-out doors and dampers on idle boilers, will tend to increase the available draft.

If the stack height is so low, or the boiler load so high, that all the above will not insure sufficient draft at all times, mechanical draft will have to be resorted to. This will in one way reduce the saving, due to added interest on investment, depreciation and operating charges with the power required, but all this can be offset by the greater boiler efficiency possible with thicker fuel beds and, consequently, higher CO_2, and greater rate of heat absorption attending higher velocity of the gas over the heating surface of the boiler and economizer.

Where the natural draft is too weak to warrant a fuel economizer, and conditions are such that mechanical draft cannot be considered, there is still a way to improve the working conditions. At least 40 per cent of the boiler heating surface is inefficient as a heat absorber because of the low temperature difference, and any increase in temperature difference will reduce the amount of heating surface required to cool the gases down to a given point.

The draft loss will not be any more with this installation than when no economizer was attached, but even less, which

can be taken advantage of by increasing the gas velocity over the added economizer heating surface. The installation could follow the European practice of building the economizer directly into the boiler setting, which would further reduce the draft and radiation losses. The economizers could also be of boiler steel since the temperature would never drop to a point where danger would exist from external corrosion, and to further prevent this, water entering should never be below 100 deg. fahr..

PROPER FEED WATER

Much heat is wasted by dirty boilers, and the cost of cleaning in most plants is considerable. Using distilled water as boiler feed should be advocated whenever possible. In other plants, more attention should be paid to treating the feed water. Properly treated feed water will not only improve the efficiency of a boiler as a heat absorber, reduce the cost of boiler cleaning and its repairs and increase its life, but will also greatly increase its safety.

City boiler inspection departments, with the aid of water departments, could be of great aid to the operating engineers in the particular cities, by keeping them informed as to what treatment the water requires to make it suitable for boiler feed. Much good could also be done by the boiler insurance companies, not only to the engineers and power-plant owners, but also to themselves, if they had chemists to inspect samples of feed water and advise proper treatment.

PREHEATED FURNACE AIR

Preheating of furnace air with the heat in the escaping flue gases would save considerable, but is never practiced. A saving of 5 per cent is easily possible and air preheaters to effect this saving could be constructed cheaply, but as they would be quite bulky they could be located outside of the boiler room. Most simply constructed they would consist of a long sheet-iron compartment through which the air and flue gas would pass. The cost of installing would be low, except if an extensive building alteration were required, but mechanical draft would be necessary since there would be not only more friction of the flue gas and less stack draft because of lower temperature, but also more power required to force the air into the furnace. These heat abstractors could be easily cleaned by hand, or like economizers.

ECONOMICAL AUXILIARIES NEEDED

While in many power plants, especially the larger ones, considerable attention is paid to the main power-generating units, the auxiliaries are ordinarily neglected. Throttling steam engines and especially direct-acting double and single pumps are too generally used. Unless they exhaust into feed-water heaters or other heating appliances, they should not be used except in very small units, or only intermittently for short periods. Substituting motor-driven triplex plunger pumps, or motor- or turbine-driven centrifugal pumps would usually result in a substantial saving. Where duplex steam pumps are preferred and the plant operates condensing, in a small plant, the exhaust steam from the pumps could be discharged into the condenser of the main units, or in a large plant, a separate condenser could be installed especially for the auxiliaries, and the discharged circulating water from the main condensers, with the make-up water, could be used to condense the steam from the auxiliaries. Using exhaust steam from reciprocating steam pumps in the low-pressure stages of a steam turbine designed for this purpose is also quite a saving.

The use of high-pressure steam in manufacturing and heating should be discouraged; while sometimes its use is warranted, generally, the use of low-pressure steam will effect a saving if the pressure is reduced through small turbines, engines, or pumps, as, thus, the mechanical energy will be extracted between the high- and low-pressure limits, without ma-

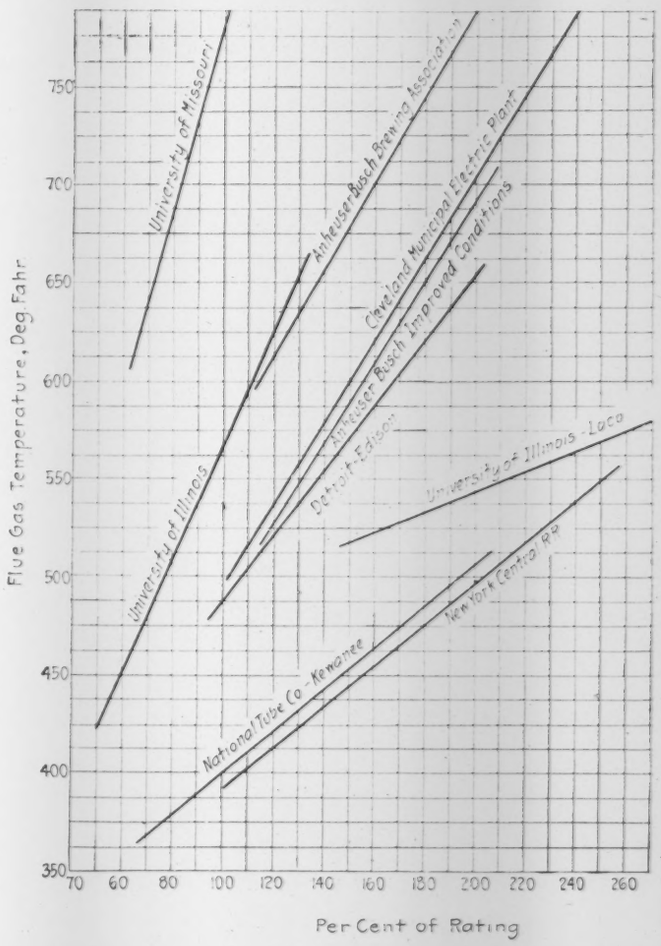


FIG. 3 FLUE-GAS TEMPERATURES AT VARIOUS BOILER RATINGS IN SEVERAL DIFFERENT PLANTS

terially reducing the heating qualities of the steam. Using large reducing valves to reduce steam pressures, while not a waste of heat, is a distinct waste of power.

UTILIZING EXHAUST STEAM

The value of exhaust steam for heating and the consequent saving effected has been demonstrated, and many plants take advantage of it, but the practice should be more general. Even plants operating condensing could bleed the low-pressure receiver of a compound engine, or the low-pressure stages of steam turbines and distribute this steam through the buildings. In power plants where economizers are not employed and the temperature of the water is low when fed into the boilers, this partly expanded steam could also be used to advantage in feed-water heaters.

EXTRAVAGANT REFRIGERATING PLANTS

About the most wasteful power plants are the ice-making and refrigerating plants; many make three or less tons of ice per ton of coal, a few about six tons, and only the very exceptional plants reach the ten-ton mark. All except the very small ones and those near coal mines, should be making ten

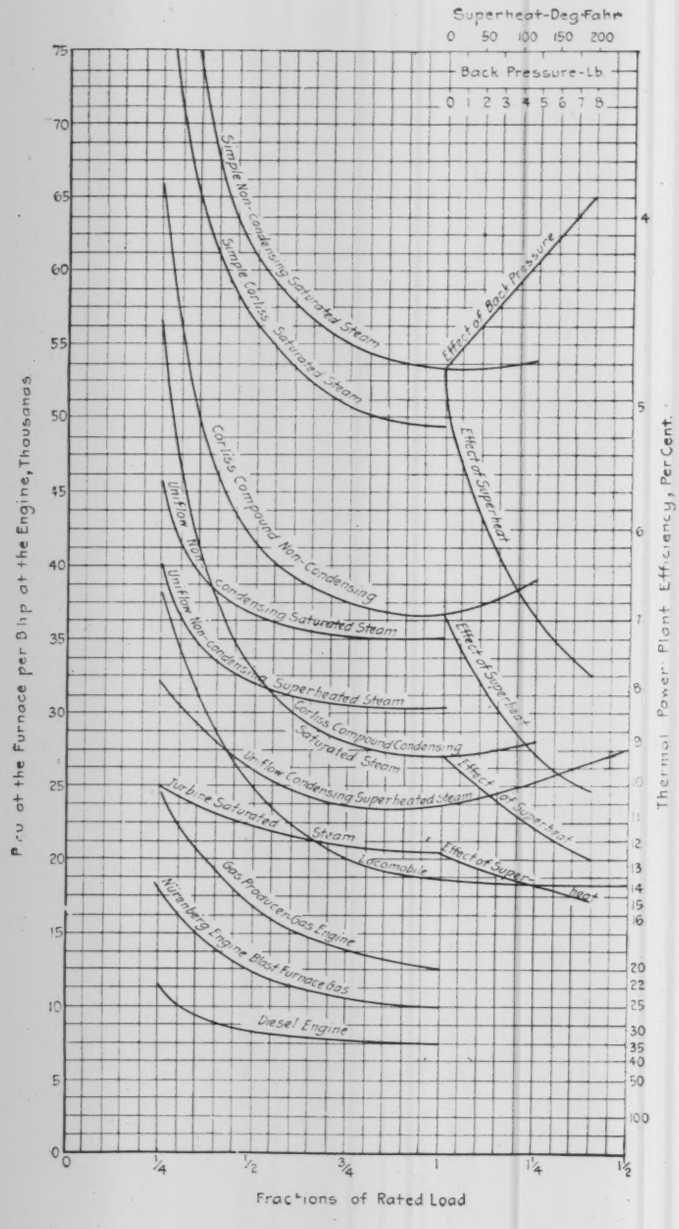

Superheat-Deg-Fahr
0 50 100 150 200
Back Pressure-Lb
0 1 2 3 4 5 6 7 8
Simple Non-condensing Saturated Steam
Simple Corliss Saturated Steam
Effect of Back Pressure
Effect of Superheat
Corliss Compound Non-Condensing
Uniflow Non-condensing Saturated Steam
Uniflow Non-condensing Superheated Steam
Corliss Compound Condensing Saturated Steam
Effect of Superheat
Uniflow Condensing Superheated Steam
Turbine Saturated Steam
Locomobile
Effect of Superheat
Gas Producer-Gas Engine
Nürnberg Engine Blast Furnace Gas
Diesel Engine
B.t.u. at the Furnace per B.h.p. at the Engine, Thousands
Thermal Power Plant Efficiency, Per Cent.
Fractions of Rated Load

FIG. 4 RELATIVE EFFICIENCY AND HEAT CONSUMPTION OF VARIOUS POWER INSTALLATIONS

tons of ice per ton of coal burned, and in no case less than six tons.

One reason for the existing bad conditions is the low load factor. While during warm weather the equipment is forced far beyond its economical rating, in winter it stands idle. This low yearly load factor, which, in most plants, is between 20 and 40 per cent, is to a certain extent responsible for many plants not being more successful and profitable. Proper-size ice-storage houses reduce the necessary size of power plants, machinery, ice tanks, etc., and consequently also the fixed and operating charges.

Besides the variable load conditions, the following are factors responsible for uneconomic conditions:

a Inefficiency in the boiler houses, where often the coal is burned with from two to four times the air actually required

b The fact that distilled-water ice is made and uneconomical prime movers and auxiliary machinery operated so that sufficient exhaust steam for distilled water will be obtained. This type of plant also condenses the exhaust steam in atmospheric condensers, with the result that the engines operate against a back pressure instead of under a vacuum

c Lack of thorough understanding on the part of many operators of the physical laws governing the compression of gases, refrigeration is often obtained with from 20 to 40 per cent more power than actually required. Many operators insist that ammonia compressors operate best with low back pressures, while exactly the opposite is true.

To be able to operate with high back pressures, ice tanks, brine tanks, and coolers should be designed and piped so that proper temperatures will be maintained without too great a temperature difference between the air (or brine) and the evaporating ammonia. Where two (one high and one low) temperatures must be maintained, the power required per ton of refrigeration will be greatly reduced by installing high- and low-pressure suction lines connecting with a multiple-effect compressor attachment, thus enabling the compressor to operate with very nearly the efficiency obtained with the higher back pressure.

Raw-water ice systems have been so perfected that ice can be made from raw water that is wholly equal to distilled-water ice. Where the water is very bad, it can be purified or a multiple-effect distilled-water system used, avoiding any occasion to employ uneconomical steam machinery to get the required quantity of ice water.

The compression system of ice making with simple non-condensing Corliss engines and its production of six tons of ice for every ton of 12,000 B.t.u. coal burned under its best conditions, high load factor and excellent operation, could be improved upon by various other combinations, as follows:

	Tons of ice per ton of coal
Compression simple Corliss, non-condensing	6
Compression compound Corliss, non-condensing	7
Compression simple Corliss exhausting into generator of absorption machine	8.5
Compression compound Corliss, condensing	9.5
Compression compound Corliss exhausting into generator of absorption machine	11.0

These estimates are for well-operated ice plants and the production could be further increased by adding special devices and by special arrangements, economizers, multiple-effect compressor attachments, flooded and jet ammonia condensers, vertical small-clearance compressors, heat exchangers, flooded systems, etc., also by using uniflow engines supplied with highly superheated steam. In some refrigerating plants Diesel and semi-Diesel engines are used to drive ammonia compressors with great success.

By operating ammonia compressors properly, that is, with a high discharge temperature and leading the gas through a

feed-water preheater, considerable heat could be saved and thus allow, if economizers are not used, employing more efficient auxiliaries or discharging their steam into the generator of the absorption machine. Condenser efficiency is also very important in ice- and refrigerating-plant operation and it is regrettable with what persistence the low-efficiency straight pipe condensers are used, while there are excellent types of flooded, jet condensers and others on the market.

Many large plants are operated non-condensing and while the exhaust steam, in winter, is used for heating, in summer, a large part of it is ordinarily wasted. It would pay some one to buy this steam and use it in an absorption ice machine. Another good combination would be an exhaust-steam absorption ice plant and electric-light plant, with the resulting high efficiency of the two combined.

Opportunities for economy in ice plants are great, not only by better equipment and arrangement, but also by better operation, for many plants are ridiculously inefficient. While operating engineers are coming to realize the importance of frequently indicating the steam engine, they are slow in becoming impressed with the importance of indicating the ammonia compressor.

ECONOMICAL PRIME MOVERS

The uniflow engine is important to the economical operation of the smaller power plants, and the locomobile also deserves honorable mention. Exhaust-steam turbines operating under proper conditions have demonstrated their benefits and should be used more generally. Superheated steam also should be taken advantage of more than it is. In very many plants substantial savings could be made by installing superheaters.

Producer-gas plants, gas engines, and Diesel engines should find a much greater application. With proper care, gas and oil engines today are entirely dependable and much more efficient than steam engines. The advisability of their use depends upon the price of the fuel, but, in any event, the burning of oil and gas under boilers should be discouraged, since they are much more economically used in gas and heavy oil engines.

The gas producer's chief economic advantage is that it can use low-grade fuels unsuitable under steam boilers. The quantities of fuel wasted at the mines could be used in gas producers supplying gas engines driving electric generators and the current distributed for sale. The economical power plant is necessarily more complicated and very often objections offered to producer-gas plants and gas and oil engines are that they require better operating men. This is so and, therefore, we must begin to develop men thoroughly fitted to operate the up-to-date power plant. One-sided development such as inventing more efficient machinery should be balanced by educating the men to properly handle it.

RELATIVE EFFICIENCY AND HEAT CONSUMPTION OF VARIOUS POWER INSTALLATIONS

Fig. 4 shows the relative value of various power installations from a thermal standpoint. Effort was made to have the given values, as far as possible, represent the average conditions.

All sizes of prime mover varied from 300 to 400 b.h.p. except the simple non-condensing engine and the locomobile which were 150 b.h.p., the turbine, 4,000 kw. and the Nürnberg gas engine, 1,200 b.h.p. Boiler efficiency in each case was assumed to be 70 per cent, an allowance of 3 per cent was made for the boiler-feed pump, and 2 per cent for leakage and condensation. For the condensing engines the auxiliary steam consumption was assumed to be 5 per cent of the total steam consumption. The temperature of the feed water entering the boiler was assumed to be 200 deg. fahr. to which point it was heated by either exhaust steam or an economizer.

For the uniflow engine when operating non-condensing with superheated steam, the superheat was 120 deg. fahr. and when operating condensing, 100 deg. fahr. with 25½ in. of vacuum. The turbine tests represent a 4,000-kw. horizontal turbine operating under 28 in. of vacuum, 175 lb. steam pressure and saturated steam. The effect of superheat is shown by the extension of the curve at full load.

The locomobile curve represents tests made on a 150-b.h.p. locomobile with a varying high-pressure superheat of 80 deg. at one-fourth load to 235 deg. at one and one-fourth load, and ordinary intermediate superheat. Since the chart was drawn upon the assumption that the boiler and grate efficiency is 70 per cent, for any other efficiency the value will be.

$$\frac{\text{B.t.u.} \times 0.70}{\text{Boiler Efficiency}} = \text{Actual B.t.u.}$$

OPERATION AND MANAGEMENT

To obtain the greatest efficiency possible in a power plant is not only a matter of design, but a good deal a matter of proper operation and management. Most power plants could make large savings in this way and there are exceptionally few where some improvements couud be made without spending a dollar for new equipment. To obtain full benefit from the equipment on hand, the men operating it must be made more efficient and this can be done by:

a Education
b Strict supervision
c Pay according to merits (Bonus systems)
d Competition and advancement
e Welfare

Education, while the most important, is also the most neglected factor in economic operation of a power plant. This is especially true in the boiler room where the waste is greatest. Skilled labor should be employed. Every boiler room should have a man with authority to give orders and with sufficient personality to have his orders respected.. This man should predetermine, by the proper use of various instruments, the most economical ways of burning coal and instruct the firemen as to the best methods, and then insist that these methods be carried out.

License laws and examinations would conduce to better education of operating engineers but in 60 per cent of the United States, by population, there is no license law, and the other 40 per cent consider only ability to operate a plant safely—seldom economic operating ability. License laws should be more stringent, examinations more complete, licenses graded and issued for intended plants. Since fuel-loss prevention is a national problem, efforts should be made to obtain a Government standard license law all over the United States, and members of examining boards should be civil-service employees of the United States Government, thus eliminating politics.

Opportunity should be offered to men, intending to become operating engineers, to acquire the necessary knowledge. While the practical part can be learned in the power plant

directly, the fundamentals of theory which are all important to the up-to-date operating engineer are difficult to obtain properly. Coöperation of educational institutions is needed by the forming of classes at the various universities and other schools to give courses on economic operation of power plants. Instruction should be given by correspondence to those unable to attend in person. Washington University of St. Louis has made the initial step in this direction by starting two night courses especially adapted to the operating engineer.

The effect that proper training of operating men would have on general power-plant conditions and economy cannot be estimated, but it would be of immense value to the owner, mechanical engineer, and also to the men themselves; in fact to the whole community.

SMOKE PREVENTION

There has been considerable agitation against smoke emission and in all important cities, smoke prevention departments have been formed and laws made against smoke emission. The objections to smoke, as stated, are "public nuisance" and "fuel loss." The methods employed by smoke departments are effective in preventing the first, but the value of some of them as to the second is very doubtful. It is well known that the chief loss in a boiler plant is due to excess air (low CO_2) and not due to incomplete combustion, of which the result might be smoke.

To prevent smoke effectively, it is necessary to center attention on the quantity of air used to burn the coal, and keeping it down to a minimum, proper furnace temperature and possibilities for well mixing, the combustible gases and the air. At present (with exceptions) most attention is paid to smoke and smoke alone, without paying the attention to excess air loss that it deserves. As a result many plants are wasting more fuel since operating smokelessly than before, because of using more excess air

Smoke prevention departments could greatly aid in preventing national fuel waste and some of them are doing so, but where they are not, it can be laid to:

a Political influence and interference
b Lack of funds to employ expert inspectors
c Employment of methods having no scientific basis, and lack of effort to educate the engineer and firemen, while at the same time more force is employed than is good for the cause
d Lack of confidence on the part of the power plant owner because of all of the above.

Exceedingly few firemen, not even 3 per cent, know the simplest rudiments of combustion Many who are considered good firemen persist in operating their furnaces so that at least 20 per cent of the fuel is wasted; at the same time claiming that it is the better and proper way. To overcome such conditions they must be educated.

It would be a great help if more of the simplest literature could be obtained, describing the economical process of firing, and this written in an interesting way. It is not meant that there is no such literature, for an immense amount of good has been done by Power, Practical Engineer, and other journals of this character, but the man who needs it most does not get it, and it would pay to bring it to him.

The U. S. Bureau of Mines would increase its usefulness by including in its excellent editions on fuel technology from time to time, bulletins of a thoroughly practical nature especially adapted to the average boiler room man. These bulletins should be written by men who know the fireman and who have been through the mill themselves. After such bulletins are ready they should not be kept until those who need them write for them, but they should be given a forced circulation with the aid of boiler insurance companies, smoke inspection departments, business men's leagues, etc.

CARE FOR THE HUMAN ELEMENT

In larger power plants, reading rooms for men waiting for the change in their shift, with some good literature, will cause the men to come, instead of ten minutes before work time, an hour or more. Also good engineering literature should be kept on file for employees to take home. Meetings should be arranged between employees and foremen at regular intervals for discussion and instruction upon the special problems coming up, new work, and better and more efficient operation. Lectures upon different subjects pertaining to efficient power plant operation should be given, and the men kept in close touch with not only the outside, but also the inside details of their work. As a result they will be more interested in their work, eager for learning and, in general, better men by whom the power plant will be operated much more economically.

In smaller plants, typewritten instructions and discussions should be edited at regular intervals and given to the men to be studied.

The proper amount of work and the most economical way of getting the results for each man should be predetermined. He should then be given his instructions, and it should be seen that he carries them out. Absolute strictness and discipline should be maintained and, at the same time, if the men do the proper amount of work, in the proper way, they should receive the right compensation for it. Good men will seldom work for low wages.

A good power-plant manager should have the welfare of his employees at heart, yet usually not even proper washing facilities are provided and the men are allowed to live under unhealthy conditions, with the result that they are not vigorous enough to give efficient service. Proper treatment of the men and just compensation for the service rendered by them is of much greater importance than is ordinarily realized. Labor troubles are usually caused by the employers themselves, through their blindness to the fact that workingmen must be treated as human beings.

Competition is the best stimulus to the attainment of more and better work, and, therefore, should be developed wherever possible. One power plant should be compared with another. The engineers of each should be put in competition with one another whenever possible, and so also the firemen, by posting their fuel loss, obtained from average CO_2 readings, upon a blackboard in the boiler room. When practical, a bonus system should be provided and men given some compensation for the extra efforts made.

Coöperation among power-plant owners and the formation of supervising engineering staffs, to take care of a number of plants would be of great value, as in this way they all would obtain expert supervision, that each alone, ordinarily, could not afford.

Replacement of small uneconomical power plants by large efficient central stations will also promote conservation of the nation's coal supply.

It was the author's aim to outline in this paper the existing weak points and expose the wasteful conditions, whose prevention is not only our duty, but also for our immediate benefit. A nation-wide educational campaign should be started and persistently carried out until results are obtained.

VALUATION PAPERS

THE Valuation Session of the Annual Meeting will be devoted to a discussion of engineers' ideas of principles and methods in the valuation of industrial properties. The Committee on Meetings hopes that the information brought out will form a valuable supplement to the large amount of material already available on the subject of economic theories of values and their application to public utilities.

THE RELATION BETWEEN PERPETUAL-INVENTORY VALUE AND APPRAISAL VALUE

By CHARLES PIEZ, CHICAGO, ILL.

Member of the Society

MOST plants grow from small beginnings, and during their early life expand as the needs dictate. The organization is necessarily small because the most rigid economy must be practiced, and original costs and the costs of additions are frequently so completely submerged in the total assets that no safe records of these costs can be established. Many plants never outgrow this lump-sum treatment of assets. In these cases depreciation of plant and equipment is either wholly disregarded, or else an arbitrary amount is charged against profits, the amount of depreciation varying inversely as the size of the profit it is desired to show.

Industries so managed need the assistance of a competent appraisal company to inform them of the value of their assets, as a basis for embarking on a sounder and safer system of accounting methods. Practically all successful industries so maintain their inventories that additions to the plant are accurately recorded, and depreciation is based on judgment and experience. But even such industries will find it to their advantage to ask the aid of appraisal companies for the purpose of determining authoritative records of the cost of reproducing plant and equipment, so that underinsurance or overinsurance may be avoided, and the basis for the requirements of co-insurance complied with.

Appraisals are also valuable in establishing comparative values of plants that are about to merge, or in serving as a basis of a scheme of financing. But the claims that an appraisal is necessary for figuring overhead costs and the selling price and profit of manufactured articles are, to say the least, sadly overdrawn.

It has been my experience that in well-managed industries appraisal values are usually considerably above sound inventory values established by the management. With the steady advance in prices that has been going on almost continually for the last twenty-five years, it is but reasonable to suppose that replacement values are substantially higher than initial costs, and it is well to establish the amount of such excess if a proper insurance coverage be desired; but such advance is wholly speculative and has absolutely no bearing on the value of the plant from the standpoint of the operating and sales management.

The establishment of true costs is an essential element in the success of a business, and true costs can only be obtained when every item of expense is included. Buildings that were adequate when first erected gradually outgrow their initial advantages, and in spite of substantial increases shown in the appraisal value, they have less value for the purposes to which they are put than they had when first constructed. They may, in fact, prove so unsuitable to the increasing needs of the business as to justify demolition and reconstruction.

Few owners foresee their needs for ten years to come, and fewer still have the means to build or expand along lines giving ample opportunity for future business growth. It is safer, therefore, to provide proper sinking funds through an ample rate of depreciation for use in reconstructing buildings that have outlived their usefulness.

Machine tools have changed very considerably as a result of the development of high-speed steels, and companies that followed appraisal methods of depreciation find themselves with obsolete equipment and no funds to replace it with modern equipment.

Patterns and small-tool equipment often have but temporary value and should disappear wholly from the inventory when they have served their purpose, yet these two items are fertile sources for inflation of values through appraisals.

What the management of an industry is chiefly concerned in is to provide a fund through a proper scale of depreciation which will reimburse it for the difference between the cost price of a piece of equipment and its fair cash selling price when sold either because it is ready for the scrap heap or because some newer form or method has made a change desirable. This difference is properly a part of the cost of the product, but becomes so only by charging depreciation against the expenses of operation.

Has any appraisal company ever investigated the subject of depreciation from the operating standpoint and recommended a schedule of depreciation for adoption? Has any appraisal company ever advocated that depreciation be distributed as an operating expense against the product? Can any appraisal company claim with any justice that it can determine proper rates of depreciation without close contact with and full knowledge of the operating conditions and operating needs of an industry? Certainly without such contact and without such knowledge the claim that successive appraisals are essential factors in the determination of costs, prices and profits, is, to say the least, pure buncombe. The primary business of an appraisal company is to determine an authoritative replacement value, and its entire organization is trained for this purpose. But when the appraisers enter the field of depreciation, operating values, and costs, they are doing their clients positive harm; for appraisals, as previously explained, have a distinct upward tendency, and the increase in value which they show as the result of wholly extraneous conditions have the effect of lulling the manufacturer into a wrong sense of financial security.

The great majority of industries charge off too little for depreciation rather than too much, and the appraisal companies, if anything, are assisting, unconsciously, of course, in increasing this unprofitable and ofttimes disastrous habit.

I had occasion recently to go over the financial statements of a manufacturing plant which had delegated the important function of depreciation to an appraisal company. The amount charged off annually was less than one-half of the proper amount, this being due, the owner said, to the constant and considerable advance in the replacement value of the

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

STANDARD DEPRECIATION RATES ADOPTED BY MANUFACTURERS' COST CONFERENCE, FEB. 25, 1916.

	Per Cent on Cost.	Per Cent on Reducing Balance.
BUILDINGS AND ACCESSORIES:		
Reinforced concrete or steel and tile	2	3
Brick and steel with non-combustible roof and concrete floors	2.5	4
Brick, steel and wood	3	5
Brick and wood	3	5
Steel frame, wooden roof and corrugated iron walls	3.5	7
Steel frame, non-combustible roof and corrugated iron walls	3	6
Concrete block, with wooden roofs and floors	3.5	8
All wood structures, well built (20 years)	4.5	10
All wood structures, cheap (20 years)	5	12
Sprinkler system (20 years)	4	7.5
Heating and ventilating system (20 years)	4	7.5
Water and sewer piping and sanitary fixtures (where separate)	4	7.5
Tanks and reservoirs, steel	4.5	10
Tanks and reservoirs, wood (10 years)	9	20
NOTE: All Repairs and Maintenance to be charged to Account 8059.		
MACHINERY AND LARGE EQUIPMENT:		
Boilers, pumps, feed-water heaters and air compressors	6	15
Power piping	6	15
Switchboards, main wiring and conduit	6	15
Engines and dynamos	5	10
Machinery, motors, machine tools, traveling cranes, etc.	4.5	10
Punch presses, bending rolls, power shears and drop hammers	4.5	10
Shafting, pulleys, hangers and belting	50	..
Machine tool accessories—Boring bars, drivers, key-seating broaches, etc. (All renewals to Repairs).	50	..
Cupolas, converters, melting furnaces and accessories	5	10
Annealing and heating furnaces, ovens, forges, etc.	5	10
Motor trucks	20	60
Storage-battery locomotives (battery renewals to Repairs)	10	30
Horses and wagons	12	35
SMALL TOOLS:		
For machines, net additions	50	..
Hand tools, net additions	50	..
PUNCHES AND DIES:		
(Standard) net additions	50	..
CHILLS, IRON AND STEEL FLASKS AND ACCESSORIES:		
Net additions	50	..
FIXTURES, FURNITURE AND MISCELLANEOUS EQUIPMENT:		
1 Steel shelving, lockers, etc.	5	12
2 Mechanical appliances, net additions	60	..
3 Departmental wiring and electric fixtures, net additions	60	..
4 Miscellaneous items (wood), net additions.	70	..
PATTERNS (Standard):		
Metal, net additions	75	..
Wood, net additions	100	..
All patterns required for a particular order or contract to be charged to the job.		
DRAWINGS:		
All new standard drawings to be charged to expense.		
All drawings required for a particular order or contract to be charged to the job.		
MISCELLANEOUS REAL ESTATE IMPROVEMENTS:		
Pavements, sidewalks, fences, retaining walls, roadways, tracks, yard drainage, general conduits, tunnels, vaults, etc.	4.5	10

property. Here was a typical case of reducing the operating burden of a plant by crediting it with a wholly speculative and unrealizable increase in property value. In this case the appraisal company specified the amount to be depreciated each year, and was therefore responsible for this wholly unsound and unscientific procedure. The owner is about to build a new plant, and I take no chances in prophesying that he has some bitter disappointments awaiting him in unforeseen shrinkages of assets when he abandons the old plant.

The problem of determining an adequate scale of depreciation is by no means a simple one, and it goes hand in hand with the problem of distributing depreciation against the cost of the product. It is astonishing to find how widely the practice among different manufacturers in the same line varies.

Largely as a result of the recommendations made by the Federal Trade Commission that the cost-accounting systems of various lines of industry be standardized, the manufacturers of conveyors and elevators have agreed on the standard schedule of rates of depreciation given herewith. The rates are but compromises growing out of the judgment and experience of the individual members of the manufacturers' conference, but their correctness can later be verified by matching the perpetual-inventory values which these rates will establish, against the actual experience of loss in cash value when equipment or buildings are discarded.

They establish, therefore, a broad basis upon which fair operating values and the shrinkage in these values, due to wear and tear and change in style, can be computed, and serve as the preliminary step to the equitable distribution of these shrinkages or depreciation in value over the cost of the product.

I recognize the value of the work done by the appraisal companies in establishing authoritative replacement values for purposes of insurance, for the purpose of comparing the physical values of various plants about to be purchased or merged, or as the foundation upon which a perpetual inventory kept by the industry itself can be based; but I am convinced that only a perpetual inventory providing for a sound schedule of depreciation, and intelligently handled by the management of the industry, is of value in determining the true cost of the product.

VALUATION OF INDUSTRIAL PROPERTIES *VS.* VALUATION OF INDUSTRIAL METHODS

BY WALTER N. POLAKOV, NEW YORK, N. Y.

Member of the Society

THE question of determining the value of the physical properties of our industrial establishments and public utilities has been recently brought to public attention. The purpose was primarily to justify the increased cost of commodity rates and transportation as gravely influenced by heavy investments in the machinery of production. Discussing the subject at the conference on valuation held in Philadelphia in November, 1915, the writer said: "The loss to the companies from the undervaluation of their property is insignificant in comparison to the actual losses due to the lack of proper operating methods. The subject of correct methods of appraising a property is completely overshadowed by the importance of determining the proper methods of using this property . . . What is needed most is the correct valuation of operating and managerial methods in vogue, and overestimating the importance of property valuation is like trying to trace old sins instead of preventing the committing of new ones."

It is a fact that the fixed portion of the capital invested in real estate and equipment has materially increased since the tractor replaced the ox plow; modern factory equipment has taken the place of artisans' tools and transportation is done

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

by rail and automobiles instead of horses. The correspondingly increased financial burden has created a new problem; how to absorb the expense of wear and tear, obligations to money lenders, etc., increased by adopting expensive machinery of production as a result of engineering progress.

The solution offered by financiers and accountants of the old school was to include in the manufacturing cost all the fixed charges of a plant and all the financial obligations of a company, irrespective of whether these investments or expenses contributed anything to the value of the commodity or in any way benefited the production. If the instruments of production were completely used up in the process this theory would be correct. However, in a typical case, the value of the instruments of production passes only partly into the cost of commodities as they are produced. Apparently the self-evident fact that the equipment not used in production cannot pass any part of its value into the product was usually obscured by a consideration that it loses value during idleness and meanwhile accumulates such charges as rent, interest, insurance, etc.

The absurdity of including these expenses of idleness in the cost of an article, already bearing its share of fixed charges, was so clearly exposed at the Buffalo meeting of this society by H. L. Gantt, that any further argument seems superfluous. *Present practice manifestly tends to charge against the cost of a product the cost of over-equipment and mismanagement, thus imposing on society the penalty for tolerating these conditions in the industries.*

The paradox that adopting improved machinery devised by designers reduces the rate of profit of the enterprise, can be explained either by the fact that the improvement is merely illusory or that an improper use is made of the improvements. No careful manager would approve a replacement or new installation of equipment unless study proved beyond any doubt that the advantages offered by such a change are ample to more than pay for the investment. When the cost of production increases after an investment is made it indicates plainly either that it was poor judgment to make the change or that the method of management does not offer the opportunity to secure the advantages inherent in the new improvement.

Nevertheless, the tendency of the average rate of profit to fall is but an expression of progressive development of the productive powers of society. Automatization, growing speed and capacity of machinery cause the same number of laborers in the same time to convert a larger quantity of raw and auxiliary materials into product. In other words, the fall of the rate of profit is not due to an absolute, but only to a relative, increase of the capital invested in means of production over its part invested in labor. This law, though seldom recognized, is actually followed in our industrial development. It requires an increasing mass of total capital for the purpose of using the same quantity of labor to secure the same mass of profit, though at a falling rate of profit. If the mass of profit is to be increased through the introduction of improved machinery (i.e., with corresponding increase of investment) without curtailing the wages or lengthening the working day, the intensity of labor must be increased.

In other words, to keep pace with industrial progress in order to meet the requirements and competition, improved instruments of production must be adopted. Increase of investment is followed necessarily by reduction of the rate of profit, and in order to secure the same or larger earnings the manufacturer must expand the production, ergo—increase the investments. This is the process we actually observe in our industrial development. No amount of pains given to the subject of proper appraisal of physical property can alter the tendency for the rate of profit to fall. Salvation is sought therefore through raising the commercial profits by increasing the selling prices. This method, although temporarily expedient, overtaxes eventually the purchasing capacity of consumers and creates a so-called business depression.

At the outbreak of this war, our country was rushing headlong into a period of industrial depression caused by surplus production that could not be consumed in the United States on account of the small purchasing capacity of the people, and could not be exported because poor shop methods prevented us from producing as cheaply as other countries. The undeveloped stage of our credit system contributed a further obstacle to the development of export. There was no incentive for us to plunge into the war since there were no foreign markets to fight for, neither could anything be gained by a territorial expansion. A crisis seemed imminent, but the loading up of our industries with European orders postponed it.

The misuse of or failure to use the expensive machinery of production is not a sufficient reason to either advance prices or to lower wages, as both undermine our future. Neither is it necessary. A manufacturer adopting superior methods of planning and managing his business, working with improved methods of production that have not yet become general, can sell below the market price, but above his individual cost of production. In this way his rate of profit rises until competition levels it down. During this period the second requisite comes into play—the expansion of the invested capital, facilitated by the previous period of accumulation. According to the degree of his expansion he will be enabled to employ all of his workmen or more; in other words, he will be enabled to produce the same or a greater mass of profits. As long as industrial development along these lines is still possible, and this possibility is accentuated not only by European experience but by our numerous experiments and successful demonstrations of the adaptation of scientific principles to the management of various industries, the revision of our methods is a paramount problem. Therefore the problem of determining the real value of our industrial and managerial methods, if properly solved, offers the opportunity of rectifying the errors of the past.

The appraisal of industrial property when accurately made discloses the fact otherwise overlooked that, as a rule, there are more means of production than are made use of, and the idle capital investments represent also idle labor. *The revenue-producing factor in our mode of production is not the investment but the method of its use. It is the business* of financiers to invest money in industries and they want to know what this investment is and what return they are getting. Ultimately the question they will ask is, *What is the value of the methods and what do they lead to?*

This statement does not imply a suggestion to appraise property according to the capitalization of the earnings. The use-value of the plant has nothing to do with its cost-value and is in the highest degree unfit for the purpose, as it varies with personnel, policy and methods. Evolution in our industrial relations will eventually reverse the present situation and all charges for unprofitable investments and non-productive forces will not be borne by the consumers, who as yet have no power nor means to take an active part in the management of the industries. Unfit methods and incapable leaders are equally harmful to both investors and consumers, and their interests unite in demanding that methods of the highest value be developed.

MACHINE SHOP PAPERS

THE Machine Shop Session of the Annual Meeting will be devoted to the discussion of the two important papers printed below. The Sub-Committee on Machine Shop Practice which will have charge of this session has been exceedingly fortunate in securing the ideas of Mr. Carl G. Barth on Machine Tool Standardization. Mr. Hathaway's paper represents the results of his experiences on this sub-committee.

STANDARDIZATION OF MACHINE TOOLS

SOME SUGGESTIONS REGARDING STANDARDS OF SPEED AND FEED SERIES AND STANDARDIZED POWER OF MACHINE TOOLS, ETC.

By CARL G. BARTH, PHILADELPHIA, PA.

Member of the Society

THE object of this paper is to try to enlist the coöperation of the Society in encouraging machine-tool builders to adopt certain standards, for even only the approximate attainments of which the writer has had to spend a large sum of money in each of a number of machine shops in which he has found such standardization highly desirable, if not to say absolutely necessary, as one of the steps in the installation of

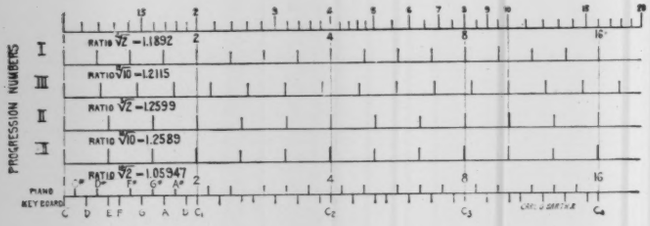


FIG. 1 LOGARITHMIC PLOT OF SUGGESTED ALTERNATIVE STANDARDS FOR SPEEDS AND FEEDS

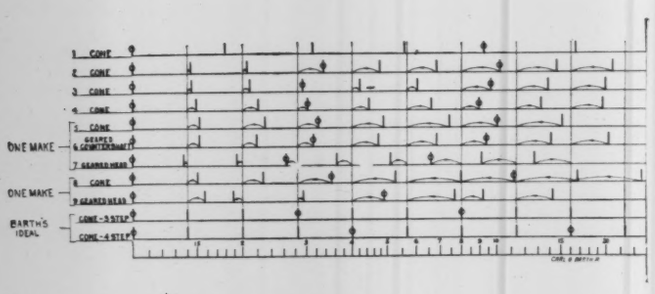


FIG. 2 LOGARITHMIC PLOT OF SINGLE COUNTERSHAFT SPEED SERIES OF NINE 16-IN. LATHES

a more or less complete Taylor System of Scientific Management as practised by him.

STANDARDIZATION OF MACHINE EQUIPMENT OF SHOP AS A WHOLE

During his many years of experience the writer has gradually been forced to see an enormous advantage in standardizing the machine equipment as a whole, aside from the standardization of the mathematical and certain constructive features of each machine. Wherever possible his effort is to have the very same make of machines only in a certain productive group, and in the expansion of such a group to add machines of exactly the same design, even to the extent of having a manufacturer furnish what is no longer his most recent product—only, however, if this or some other manufacturer's most recent product is not a sufficient improvement over the old to warrant the introduction of a new machine as a new standard for the work to be done, with the intention that this type will eventually crowd out and replace the older type.

STANDARD SPEED SERIES

As in the present state of the science and the art of cutting metals, it is, on the average, impossible to determine the most economical or suitable speed and feed at which to run a machine for any set of conditions closer than a certain percentage, it is by this time universally accepted by those who have a right to an opinion in the matter, that the available speeds of a machine should be in a geometrical progression.

This being agreed to, the writer's idea is that a universal speed series should be adopted by all machine-tool builders for all machines such as lathes, boring mills, milling machines, drill presses, etc. that are provided with a spindle for either the work or the cutting tool, and which, except in the case of certain single-purpose machines not included in this discussion, may be rotated at different speeds; for our present knowledge does not warrant us in asserting or assuming that a progression of speeds for one kind of these machines should have a lesser or a greater constant ratio than for any other kind; and, evidently, if there is no reason for making them different, there is every reason for making them just alike. The question then becomes, what should be the constant ratio of such a universal geometrical progression of speeds?

As far back as 1888 the writer designed for William Sellers & Company, Inc., of Philadelphia, a large lathe which had 30 speeds in a practically perfect geometrical progression, with a ratio of a little over 1.15, obtained by a correct relation between a 5-step cone, two back-gear reductions and two forward speeds of the countershaft. Again, in 1892, he designed another with 36 speeds which had a practically constant ratio of but little over 1.14, obtained by a 6-step cone, two back-gear reductions and two forward speeds of the countershaft.

These designs, only the latter of which was actually built, prove that this company was long ago able to appreciate the theoretical value of close speed regulation, though at that time the prevailing style of shop management, or, rather, lack of shop management, throughout the country was such that the knowledge was undoubtedly of no practical value to the generators even in the shops of this company. In fact, when the writer finally got some real ideas about such matters during his first two years of association and coöperation with Mr. Taylor at the works of the Bethlehem Steel Company, immediately after Mr. Taylor and Mr. White had made the discovery of the high heat treatment of tungsten steels, he realized that he had overreached himself in those two lathes. Therefore, in designing some special lathes for the Bethlehem Steel Company for the better utilization of high-speed tools, he

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

adopted 1.2 as a more rational ideal, and he has never since found any reason for deviating materially from this ratio; though it was several years later before he recognized the desirability of an absolutely constant ratio, not only for all lathes, but, as referred to above, for all machine tools with a revolving spindle.

However, if we construct a geometric progression with this simple ratio 1.2 and beginning with 1, all subsequent terms of this will naturally be found to be anything but simple numbers, thus: 1 1.2 1.44 1.728 2.074 2.488 2.986 3.583 4.300 5.160 6.192 7.430 8.916 10.70 12.84 15.41 18.49 22.19 26.62 31.95 38.34 46.00 55.21 66.25 79.50 95.40 114.5 137.4 164.9 197.8, etc.

FIG. 3 LOGARITHMIC METHOD FOR GETTING CLOSEST APPROXIMATION TO A GIVEN RATIO WHEN TWO SETS OF GEARS ARE INVOLVED

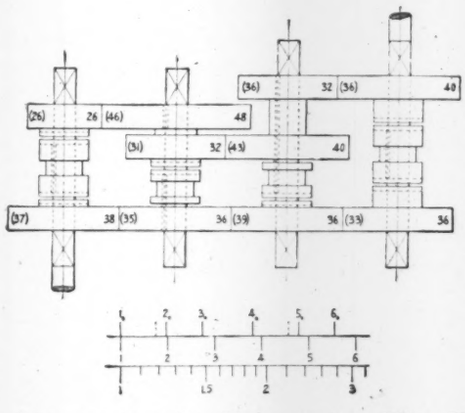


FIG. 4 DIAGRAM OF SPEED VARIATOR OF A WELL-KNOWN MAKE OF PLANER

(Figures in parentheses show number of teeth in gears as made; other figures show number of teeth to improve the speed series. 1_o to 6_o = logarithmic plot of original relative speeds; 1 to 6 = logarithmic plot of improved relative speeds.)

In reality, therefore, we will have a simpler progression by slightly modifying this ratio 1.2 such that the fifth term becomes 2 instead of $1.2^4 = 2.074$, for then the whole progression becomes

1	$2^{\frac{1}{4}}$	$2^{\frac{2}{4}}$	$2^{\frac{3}{4}}$	2	$2.2^{\frac{1}{4}}$	$2.2^{\frac{2}{4}}$	$2.2^{\frac{3}{4}}$	4 etc.,
1	1.1892	1.4142	1.6818	2	2.3784	2.8284	3.3636	4 .....[I]

or with every fourth term a power of 2, the simplest of all numbers except unity itself.

This is, to the writer, an exceedingly attractive progression and represents his ideal for some six years past. For lack of a better term, he has named a series of speeds conforming to the above geometrical progression a *chromatic* speed series, though the term chromatic in connection with a musical scale has reference to the geometrical progression involved, rather than to the ratio 2 of the number of vibrations of two notes an octave apart.

It may be, however, that the majority of machine-tool builders will consider the ratio $\sqrt[4]{2} = 1.1892$ unnecessarily small, and would deem a somewhat larger ratio preferable, in order to obtain a larger final ratio between the slowest and the fastest speeds of a machine which, for one consideration or other, may have to be arranged with a rather limited total number of speeds, as, for instance, a lathe with a single back-gear reduction, or a small drill press or milling machine with no back-gear reduction at all.

The writer's answer is, that he has had in mind also as a possibly more generally acceptable progression, one with the constant ratio $\sqrt[3]{2} = 1.2599$; that is,

1	$2^{\frac{1}{3}}$	$2^{\frac{2}{3}}$	2	$2.2^{\frac{1}{3}}$	$2.2^{\frac{2}{3}}$	4	$4.2^{\frac{1}{3}}$	$4.2^{\frac{2}{3}}$, etc., or
1	1.2599	1.5874	2	2.5198	3.1748	4	5.0397	6.3496.....[II

which is as much entitled to the name chromatic as is progression [I].

Again, as a compromise between progressions [I] and [II], and to favor a possible preference for a progression with 10 rather than 2 as a periodically recurring ratio, the following progression may also be looked upon as a candidate:

1	$10^{\frac{1}{12}}$	$10^{\frac{2}{12}}$	$10^{\frac{3}{12}}$	$10^{\frac{4}{12}}$	$10^{\frac{5}{12}}$	$10^{\frac{6}{12}}$	$10^{\frac{7}{12}}$	$10^{\frac{8}{12}}$, etc., or
1	1.2115	1.468	1.778	2.154	2.610	3.162	3.831	4.642.....[III

The constant ratio of this progression $\sqrt[12]{10} = 1.2115$ is very close to the geometrical mean of the ratios of progressions [I] and [II], which is $\sqrt{2^{\frac{1}{4}} \cdot 2^{\frac{1}{3}}} = 2^{\frac{7}{24}} = 1.224$.

And, finally, a certain interesting simplicity would also be introduced by the adoption of the constant ratio $\sqrt[10]{10} = 1.2589$, thus:

1	$10^{\frac{1}{10}}$	$10^{\frac{2}{10}}$	$10^{\frac{3}{10}}$	$10^{\frac{4}{10}}$	$10^{\frac{5}{10}}$	$10^{\frac{6}{10}}$	$10^{\frac{7}{10}}$	$10^{\frac{8}{10}}$, etc.,
1	1.2589	1.5848	1.9953	2.5119	3.1623	3.981	5.012	6.310....[IV]

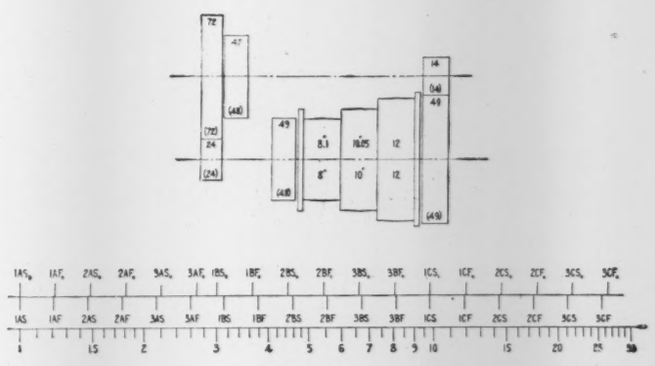


FIG. 5 DIAGRAM OF LIVE HEAD OF A WELL-KNOWN MAKE OF LATHE

(Figures in parentheses show respectively number of teeth in gears and diameters of cone pulleys as made; the other figures indicate a simple change that would further improve a very good speed series. 1 AS_o to 3 CF_o = logarithmic plot of original speeds; 1 AS to 3 CF = logarithmic plot of improved series.)

It will be noticed, however, that there is in reality a theoretical difference only between progression [II] and this progression, the tenth number (7.943) of this being less than 0.8 of one per cent smaller than the tenth number (8) of the former.

But the best comparison of these four progressions is made by plotting them on a logarithmic scale, as in Fig. 1, on which is also plotted the progression that represents the relations between the number of vibrations of the strings of a piano, the constant ratio of which progression is $\sqrt[13]{2} = 1.05947$.

Having thus indicated that there may be a choice of standards, the writer gives in the paper strong reasons for favoring progression [I], admitting at the same time that under

certain conditions every other term may be omitted, thus leaving the progression

1	$\sqrt{2}$	2	$2\sqrt{2}$	4	$4\sqrt{2}$	8	$8\sqrt{2}$	16, etc.,
1	1.4142	2	2.8284	4	5.6568	8	11.3137	16.....[V]

Progression [I] represents a fair average for the speed series provided by certain well-known machine-tool builders in some of the machines produced by them in recent years, after they had realized that the time had come for the provision of closer speed regulation, even if this meant a considerable reduction of the ratio of the fastest to the slowest speeds obtainable.

An example of this fact is represented in Fig. 2, which shows the speed ratio of nine 16-in. lathes offered by six different manufacturers in answer to an inquiry in February, 1914. One manufacturer offered three different designs and a second two different designs. It will be noted that the difference between the speed series provided in the different designs of the same maker, differ as much among themselves as do the designs of different makers, except in the case of lathe No. 1, which represents the least up-to-date design.

To make the diagram clearer, the speed ratios are laid out for a single forward countershaft speed only, thus showing only every other ratio of the full progression intended.

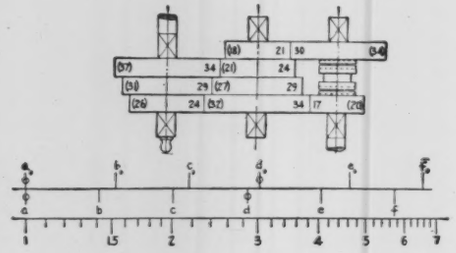


FIG. 6 DIAGRAM OF GEARS IN FEED BOX OF A WELL-KNOWN MAKE OF DRILL PRESS

(Figures in brackets show number of teeth as made; other figures show improved number of teeth.
a_0 to f_0 = logarithmic plot of original relative feeds;
a to f = logarithmic plot of improved relative feeds; these conform quite closely to Progression V, p. 969.)

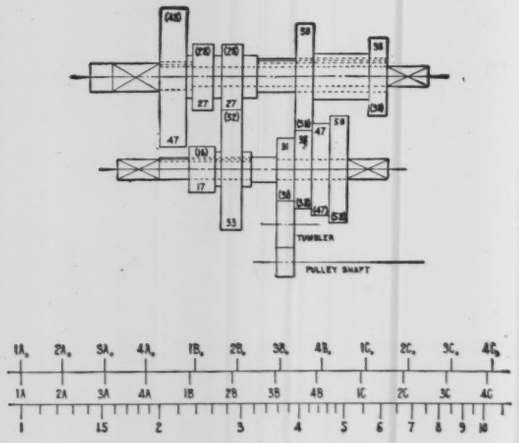


FIG. 7 DIAGRAM OF DRIVING GEAR OF A WELL-KNOWN MAKE OF MILLING MACHINE

(Figures in brackets show number of teeth in gears as made; other figures indicate number of teeth in gears to further improve an already excellent speed series.)

Most designers of the present day, whether mathematically inclined or not, are familiar with the use of the simple slide rule in selecting practical numbers of the teeth for a gear and pinion of a single set of gears to give a certain ratio as closely as possible, but a simple logarithmic scale method for getting the closest possible approximation to a given ratio when two sets of gears are involved, which the writer has used for some years past, is not generally known, if indeed at all known to anybody who has not worked with the writer in connection with these matters.

This method will be fully disclosed by a single illustration embodied in the diagram Fig. 3, and we will take for our example the ratio $4\sqrt{2} = 5.6568$, with the restriction that neither pinion is to have less than 14 teeth, and that the sum

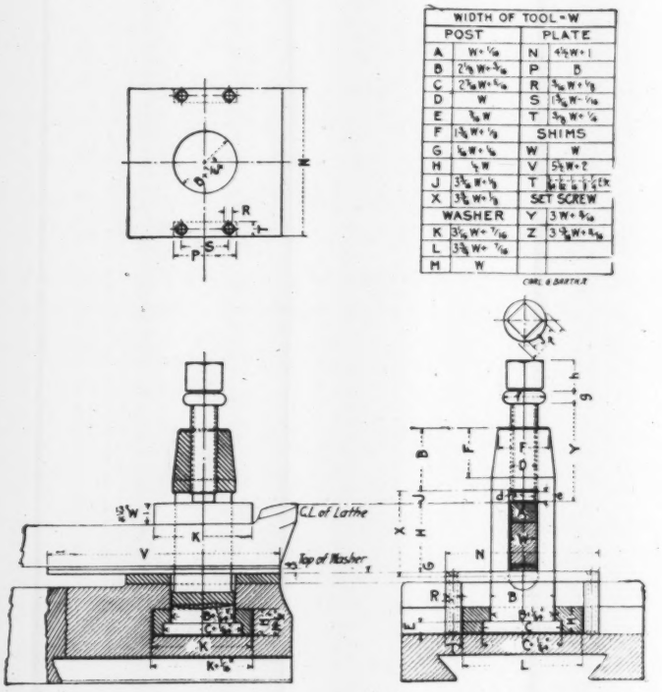


FIG. 8 PROPORTIONS USED BY AUTHOR FOR SWIVEL FORM OF TOOL POST FOR MODERATE-SIZED LATHES

of the numbers of the teeth in the one set of gears is to be 80, and in the other 60.

By means of a logarithmic scale which is shown just below the significant part of the diagram, lay off the ratio 5.6568 from *a* to *b*. Now place the graduation point for 14 on the logarithmic scale, representing a pinion of 14 teeth, at *a*, and make a mark at the graduation point representing the gear that would be a mate to this pinion, namely one having $80 - 14 = 66$ teeth. This operation is indicated by the logarithmic scale above the significant part of the diagram. The distance *ac* then represents the ratio 66/14. Similarly, 15 is placed at *a* and a mark made at 65, 16 is placed at *a* and a mark made at 64, and so on, as far as will eventually appear necessary. Next, below the line place the graduation point 14 at *b*, and mark off toward *a* the point for the mate for this pinion in the second set of gears, namely, $60 - 14 = 46$, repeat for 15 and 45, 16 and 44, etc.

On completion of this repeated operation we at once discover that the closest coincidence between the marks on both sides of the line *ab* is for the two sets of gears 65/15 and

34/26, whose combined ratio is 5.6667, which is less than 0.2 of one per cent greater than 5.6568.

It will also be seen that the two combinations $\frac{59}{21} \times \frac{40}{20}$ and $\frac{58}{22} \times \frac{41}{19}$ come quite close to the required ratio.

Of course, special requirements may often complicate a problem of this kind in various ways, but the method described can always be used as a help in its solution. However, no further consideration will be given the matter here.

To further emphasize how even some fair attempts at regular progressions of speeds and feeds have fallen short of what might have been attained, Figs. 4, 5 and 6 are submitted as a few of numerous cases that have been investigated by the writer.

Fig. 7 also shows how even a quite excellent speed series may be further improved.

STANDARD FEED SERIES

What has been said above in discussing the adoption of a standard speed series, holds equally good about a standard feed series, except for the most up-to-date designs of lathes, in which the feeds for plain turning are obtained as a constant fraction of the screw-cutting feeds. For these latter it is suggested that both the cross feeds and the longitudinal feeds be made the same fraction of the screw-cutting feeds for all lathes regardless of size.

D BOLT DIAM	A ½ D	B ⅝D+⅛	C 1¼D−⅛	E ⅝D+⅛
⅜	3/16	11/32	13/16	1/32
7/16	7/32	13/32	15/16	1/32
½	¼	15/32	1	1/32
9/16	9/32	½	1 1/32	1/32
⅝	5/16	17/32	1 1/16	1/32
¾	⅜	19/32	1 3/16	1/32
7/8	7/16	21/32	1 5/16	1/32
1	½	11/16	1 7/16	1/32
1⅛	9/16	23/32	1 9/16	1/32
1¼	⅝	25/32	1 11/16	1/32
1⅜	11/16	13/16	1 13/16	1/32
1½	¾	27/32	1 15/16	1/32

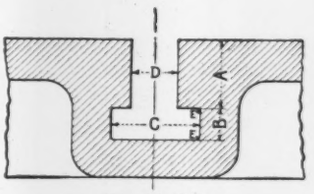


FIG. 9 AUTHOR'S PROPORTIONS FOR T-SLOTS

TOOL POSTS FOR LATHES

In Fig. 8 are shown proportions for the swivel form of the tool post for moderate-sized lathes which the writer has used as a standard for several years past. The most essential part of this, as regards size, is the width of the slot, which is for a tool body of approximately 1/30 of the swing of the lathe over the bed, and a distance from the center of the lathe to the tool-supporting plate that corresponds to the ground height of the roughing tools shown in On the Art of Cutting Metals. The propriety of these propositions is decidedly open to discussion, particularly the latter.

T-SLOTS

An exceedingly important part of the machine equipment of a shop are the T-slots in various machines, and the writer has also spent a great deal of money in bringing these to a standard, a matter that has at times meant entirely new face plates or tables for some machines.

A great many years ago experiments were made by William Sellers & Company to ascertain the strength of T-slots relatively to a T-headed bolt, and on the strength of these, that company adopted a standardized set of slots, which, as later modified by the writer, have also been used by him for several years past. They are shown in Fig. 9.

LATHE CENTERS AND DRILL-PRESS AND MILLING-MACHINE SOCKETS

It is well known that the Morse standard sockets are no standards at all, but a perpetuated, laudable, but unsuccessful attempt of years ago to establish standards. However, compelled for the time being to accept them as they are, everybody has now at least two standard tapers for sockets and shanks to contend with, namely, the Morse, and the Brown and Sharpe. The best the writer has been able to do, therefore, has been to make all lathe centers conform to a Morse Standard, so as to enable drills or drill sockets to be directly inserted in either spindle of certain or all lathes in a shop; and to make all milling-machine sockets conform to the Brown and Sharpe Standard, with Morse drill sockets having Brown

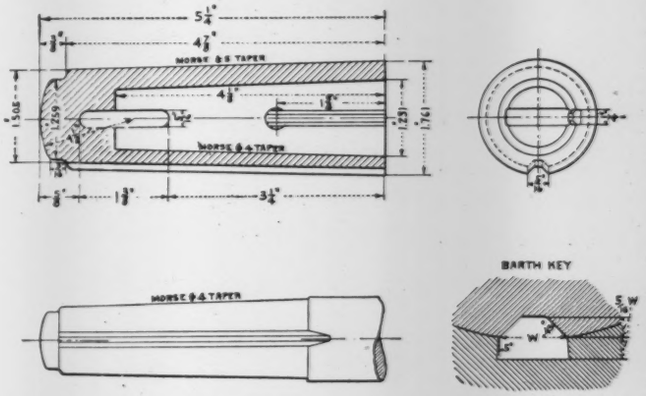


FIG. 10 AUTHOR'S KEY METHOD OF DRIVING DRILL, ARBOR AND BORING-BAR SHANKS

and Sharpe shanks for use with these, whenever holes have to be drilled in a milling machine.

The writer unqualifiedly recommends the universal adoption of the Brown and Sharpe Standards all around, and the use of Morse sockets with Brown and Sharpe shanks during the change. He also recommends the universal abandonment of the tang as a means of driving. We have now for years had the ridiculous inconsistency of drill makers, that they still furnish taper-shank drills with the old-style tang as a means of driving, and along with this extensively advertise and sell various forms of "use-them-up" sockets for drills with the original tang broken off.

More than twelve years ago the writer adopted a modification of William Sellers & Co.'s key method of driving as a substitute for the tang of drills, arbor and boring-bar shanks. This is illustrated in Fig. 10, and differs from the Sellers method in the special form of key, which has become somewhat known as the Barth key. The virtue of this as a means of driving consists in its being subjected to crushing pressures only, and that it has no tendency to work out of its seat; and for a taper-drill socket it has the additional great advantage over the Sellers straight key, that the drill shank can be inserted rapidly without any special care.

A PROPOSED PLAN FOR THE ACTIVITIES OF THE MACHINE SHOP PRACTICE SUB-COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

BY H. K. HATHAWAY, PHILADELPHIA, PA.
Member of the Society

THE writer has been impressed with what seems to be a weakness in the organization and conduct of all scientific and technical societies. Such societies, he believes, should be the agencies through which constructive work of a definite character leading to the development of a profession should be carried on. The proceedings of such societies should provide authoritative and usable data covering the entire range of activities in their respective fields.

Such data should be grouped and codified in accordance with a logical scheme of classification and indexing which would bring together in the most accessible and usable form everything pertaining to each of the divisions and subdivisions of the science or art.

A definite plan of action should be worked out for procuring from the members best qualified papers dealing with each subject covered by the classification, so that when properly arranged these papers would constitute a classified reference library covering the whole field of the science or art.

It might be pointed out that in the past the securing of papers has been a very haphazard affair, it being largely left to chance that members in a position to add to the knowledge of their profession share with their fellow members the results of their experience. Very often those best qualified to write on a given subject, by reason of their own familiarity with it underestimate its importance and the lack of knowledge of the subject on the part of others. Modesty, a feeling of inadequate literary ability, or a disinclination to share with others may prevent the presentation of papers which would be valuable contributions to a society. Frequently papers cover in a superficial way a multitude of subjects or phases of a subject, any one of which, if properly developed, might furnish material for a volume. Often a member may be moved to present a paper on a subject interesting him intensely at the moment but which may be of infinitely less value than would be one on another subject which he is preëminently qualified to handle.

In the creation of committees dealing with the several broad divisions of mechanical engineering, our Society has taken the first step toward carrying out such a plan as the writer offers for consideration. Now to make the work of these committees more effective there should be, first a predetermined plan, and second, the permanent employment of a secretary who, under the guidance of the committee, would devote his time to carrying out this plan.

While the writer has specifically in mind the activities of the sub-committee on Machine Shop Practice, such a plan might profitably be considered in connection with the work of all other sub-committees of the Society.

In addition to providing a plant and a classification of Machine Shop Practice, the sub-committee should classify the members with respect to the phases of machine shop practice on which they might be best qualified to present papers, and then make a consistent effort to secure the papers, giving adequate time to properly handle the subject.

Plans for securing papers should be made much further in advance than is possible under the present scheme where a new chairman is elected each year and expected to provide papers for the meetings during his year of office. So far as his year of office is concerned, it would seem to be better if instead of devoting his time to securing papers for presentation during that year he were to devote his time to securing papers for the next year.

Gathering in and codifying all knowledge concerning the best existing practice should represent only one phase of the work of the sub-committee on Machine Shop Practice.

A second and even larger undertaking would be the prosecution along predetermined lines, of research that would result in definite advancement of the art. At present this is almost entirely left to the enterprise of individuals or companies, and there is no coördination of effort.

Experiments along identical lines may be carried on by several different individuals or companies without any one of them having knowledge of what the other is doing, thus resulting in considerable waste of effort, time and money, and frequently in conflicting results. The writer happens to know, at the present time, of two sets of experiments being carried on independently in the art of drilling to accomplish some such work as was done by the late Frederick W. Taylor and his associates, as covered in a paper to the Society on "The Art of Cutting Metals," and Taylor's "Experiments in the Use of Leather Belting." Much remains to be done in the study of cutting metals. For example, there is little available knowledge on the subject of cutting brass and bronze, on tapping, on the use of milling cutters, etc.

The only thing that is done by societies such as ours in the way of research is that undertaken by committees of men whose time is so fully occupied by their own affairs that they can at best give an insufficient amount of time to the problem they have in hand, and are obliged to carry on at their own expense such experiments or research as may be necessary to reach a conclusion.

Would it not be better for all concerned if the Society were in a position to employ experts for investigation and research who might give their entire time to the work assigned them? Would not the results be achieved much more quickly and at less expense to the profession as a whole, and more particularly to those industries to whom the results would be of immediate value?

The first part of this plan, that of gathering in, codifying, and making available all existing knowledge pertaining to the profession, is something which might be undertaken at once. The writer has worked out a classification of machine shop practice which is appended to this paper (the classification is not included in this résumé), and in doing so has endeavored to so arrange it as to permit of easy expansion and correction. In the matter of determining who among the membership is best qualified to write upon the various subjects, help must be had from all of the members.

The second part of the plan, that of conducting, along predetermined lines, investigate and experiments for the purpose of advancing the art and providing scientifically determined information in place of opinion, calls for an outlay of money which would have to be financed probably by subscriptions from the individuals and companies who might be benefited by this work.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application All papers are subject to revision.

GAS POWER PAPERS

THE Sub-Committee on Gas Power will have charge of a session at the Annual Meeting, at which important papers on gas manufacture, gas analysis, comparison of steam and gas engines, internal-combustion engines, and gas tractors will be presented. Two of the papers for this session were given last month, and two more are published below.

A GAS PRODUCER FOR BITUMINOUS FUEL

By O. C. BERRY, LAFAYETTE, IND.

Non-Member

WHEN bituminous coal is gasified in a standard updraft producer of the anthracite type, the volatile hydrocarbons are liberated immediately. These vapors mix with the hot producer gas leaving the fuel column, and, upon cooling condense in a fog of finely divided particles of tar that, depositing, will clog up pipe lines, stick valves, and prove a general nuisance. Therefore, the special problem in designing a bituminous gas producer is to eliminate this tar from the gas.

The most obvious solution is a mechanical tar extractor that will remove the tar without affecting the quality of the gas in any other way. The plant manufactured by R. D. Wood & Co., and used by the United States Geological Survey in its experimental plant at St. Louis, is probably one of the best examples of this type of a bituminous gas producer. A second solution is to eliminate the tar vapors in the fuel column of the producer itself. This may be accomplished by applying one or both of the following well-known principles:

a If tar vapors are caused to pass through a bed of incandescent fuel, they will be "cracked," or split up into permanent gases, such as CH_4 and free H_2, and lamp black, or finely divided particles of pure carbon. Thus the tars may be destroyed completely, and a considerable quantity of valuable fuel gas will result

b Tar is a mixture of many complex hydrocarbons, and will therefore burn to CO_2 and H_2O. These gases may be passed through the incandescent fuel and split up into CO and free H_2, the same gases that are obtained in the gasifying anthracite coal.

The multiple-combustion-chamber producer, the downdraft producer with a combustion zone at the top and one at the bottom, and the recirculating producer, which is discussed in this paper, are all examples of this second class.

The volatile matter may all be driven off from a bituminous coal at a temperature considerably below the highest attained in a gas producer. In the recirculating producer advantage is taken of this fact by drawing the finished gas from well below the top of the fuel column, where the coal is sufficiently hot for the last trace of tar to have been removed. The tar-laden gases from the top of the producer are re-entered into the fuel column near the bottom. In the Whitfield producer they are introduced directly into the "incandescent" zone, while in the Daniels producer and several others they are passed into the combustion zone of the fuel column.

Fig. 1, from the patent drawings of Charles Whitfield, illustrates the general idea. The coal is trapped into the producer at the top, and the only air inlet is below the grates. The producer is kept almost filled with fuel, so that the outlet for the finished gas is well down toward the center of the fuel column. All of the combustion takes place just above the grates, forming a layer of ash immediately above them, a combustion zone just above the ash, an incandescent zone just above the combustion zone, and distillation zones of decreasing temperature continuing toward the top of the fuel column. The recirculating pipe *A*, in which flow is induced by the steam nozzle *B*, takes the products of distillation from the top of the producer down to and into the incandescent zone. The annular chamber *C* extends entirely around the producer, and makes it possible to distribute the tarry vapors to all sides of the incandescent zone.

In developing a producer of this type, information was

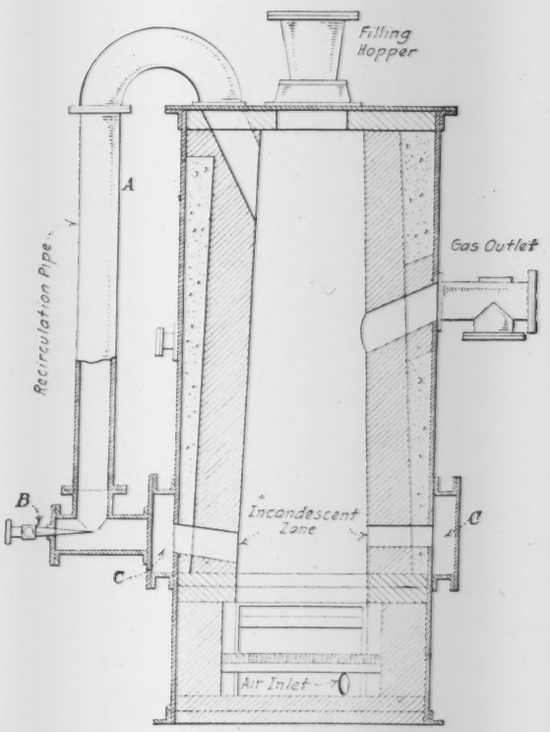


FIG. 1 WHITFIELD RECIRCULATING PRODUCER

needed that could not be found in print, and that therefore required special investigation, such as:

a The most efficient and best type of blower to use

b The temperature at which the pipe, the blower and the gases themselves must be kept to recirculate the gases with the least deposit of their tar content, and the least trouble from other sources

c The temperature at which the top of the fuel column must be held to prevent troublesome tar deposit there

d The lowest temperature at which one may be certain that the last trace of tar has been removed from the coal used.

The author has done investigative work along each of these lines. This work was started at the University of Wisconsin, but most of it has been done in the laboratories of Purdue University.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

THE RECIRCULATING BLOWER

In good anthracite-producer practice about one-half pound of steam should be decomposed per pound of combustible burned. This steam is mixed with the air for combustion as it enters the fuel column, and is obtained either from a vaporizer on the producer itself, or from some outside source. The possibility of using this steam to circulate the gases was taken advantage of by the earliest investigators. The steam exhauster is so obviously the best type of blower to use that the problem simplifies itself into a choice of the type of the steam blower.

A very inefficient blower can deliver the required amount of gas with less than a half-pound of steam, but some classes of bituminous fuel contain so much moisture that a highly efficient blower is desirable. This, with other requirements that the blower must meet, are as follows:

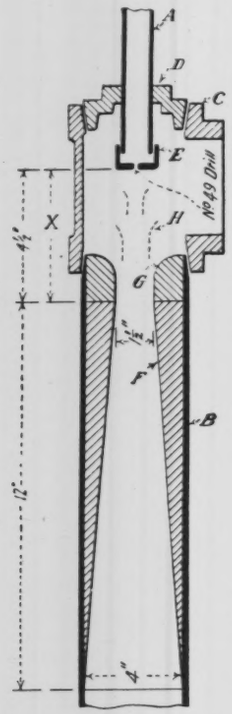


FIG. 2 RECIRCULATING BLOWER

a The required quantity of gas must be delivered with the least steam
b The blower must be capable of operating continuously without clogging up or varying from its normal delivery of gas
c In delivering the gas the blower must not cause the precipitation of too much of the tar
d The blower should be accessible and easily cleaned
e Since change in the character of the fuel column will change the pressure against which the blower works, the blower's capacity must not be appreciably affected by the discharge pressure.

Comparative tests were made on three blowers, all using the same amount of steam per hour, and all working against the same back pressure. The construction of the blower from standard pipe and fittings may be understood from Fig. 2. The Cap *E* on the pipe *A* was drilled with a No. 49 drill. Within the pipe *B* is a wooden cylinder *F* bored out to a taper, and above this is a throat piece *G*, rounded at the top as indicated; the two blocks together form the expanding pipe of the blower.

When set up as indicated, the stream of steam from the hole in *E* will pass along the center line of the pipe *B*, and the whole apparatus will serve as a steam exhauster, the air being drawn in at the side opening of the tee *C*, and forced out through *B*. By screwing the pipe *A* in the plug *D*, the distance from the lower end of *E* to the upper end of *F* could be varied from ½ to 7 in. The throat pieces *G* were made of different shapes and lengths, and the cylinders *F* in lengths varying from 4 to 12 in. Likewise the pipe caps *E* were supplied with holes of different sizes. The large number of duplicate parts was provided so as to arrive experimentally at the combination giving the highest efficiency and best performance.

The second blower was the same as the first, except that the steam orifice *E* had a number of holes placed so as to distribute the steam evenly over the entire area of the top of *F*. The size of the holes was chosen so as to use the same amount of steam as the nozzle in the first type with which it was compared.

The third type was the same as the first except that a varying number of air-expanding pipes was used between the steam orifice and the final air-expanding pipe, as indicated by the dotted lines at *H* in Fig. 2. These pipes were used in a variety of numbers, sizes, shapes and spacings, in an attempt to get at the best combination for the conditions under which they were to operate.

The results showed that type 1 was most efficient, most dependable for continuous performance with the least chance of trouble, and easiest to clean. The following general conclusions may be drawn from the result of these tests:

a In working against small back pressures probably the most efficient and best type of steam exhauster is the one shown in Fig. 2
b The height of the steam orifice above the expansion pipe is important
c The length and the angle of taper used in the expansion pipe are both important
d The capacity of the blower is almost directly proportional to the steam pressure at the orifice
e In a separate set of tests it was shown that superheated steam gave better efficiency and threw down less tar than saturated or wet steam.

PROPER TEMPERATURE FOR THE RECIRCULATED GASES

The second line of investigation was to determine the temperature at which the recirculated gases, the blower and the recirculating pipe should be held to throw down the smallest amount of tar and give the least trouble. One of the most searching tests for tar is to cause the gas to impinge against a hard surface at a high velocity. This was done, the gas and the surface impinged against being held at different temperatures during the different trials.

The apparatus used is shown in Figs. 3, 4 and 5. The gas was generated in a furnace made of a 24-in. length of 6-in. pipe, fitted with a coupling and plug at both top and bottom, and with a set of grates near the bottom. This is shown at *A*, Fig. 3. The air blast was furnished by the blower *B*, and the pressure of this blast was steadied through the tank *C*. The fumes from the furnace were carried away through the pipe *D*, the pressure inside of the furnace and the quantity of

blast passing through it being regulated by the valve at the top of tank *C* and the valve on the pipe line *D*. The pressure in the furnace was indicated by the mercury manometer *E*.

The apparatus for testing for tar is shown at *F* and a cross-section is given in Fig. 4. Here *A* is the side of the furnace, which is connected by a short nipple to the ¾-in. cross *B*. The thermometer *C* is securely packed in the plug *D*, and extends directly into the stream of gas. The steel plug *E* is threaded to fit *B*, and is also threaded into a steel bar *F*. The outer end of *E* and the corresponding face of *F* are machined to a single finished surface, and the copper block *G* is clamped against this surface. The copper block furnishes the surface against which the gas is to impinge. It is a good conductor of heat, so that it is possible to keep all parts of the block at nearly the same temperature.

The shape of the block is indicated in Fig. 5. The ends are drilled as shown at *a* so that a blow-pipe flame may be directed into each hole to aid in heating the block. The face of *G* bearing against *F* is milled out as shown at *c* to furnish

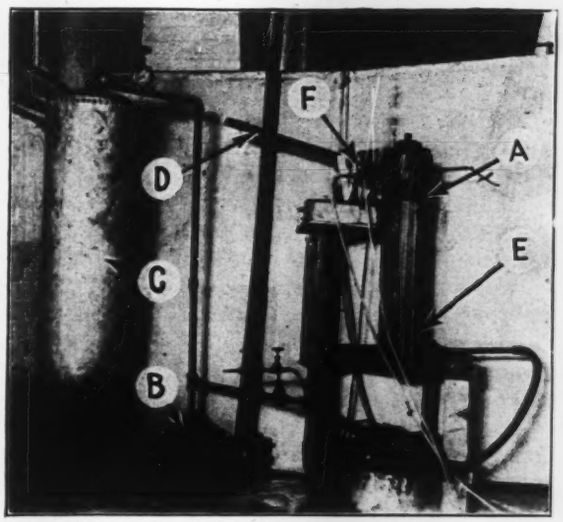


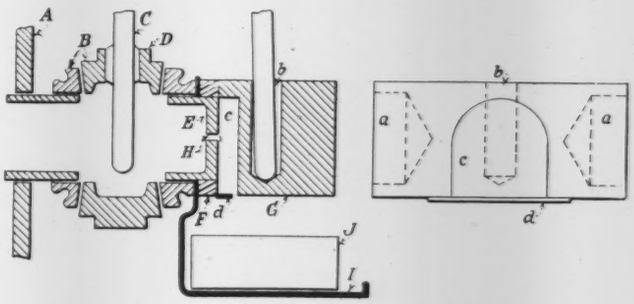
FIG. 3 APPARATUS FOR DETERMINING PROPER TEMPERATURE FOR RECIRCULATED GASES

an eddy chamber for the gases, which would impinge against it at a point directly opposite the orifice *H* in the plug *E*. The temperature of the surface of the block at this point is indicated by a thermometer in a mercury bath in the hole *b*. To prevent eddy currents of cold air from passing up into the milled chamber *c*, it was found necessary to restrict the outlet by the strip of sheet steel *d*.

In Fig. 4, *I* is a sheet-steel platform designed to hold a paper tray *J* to catch any tar that is deposited in *c* and runs out at its lower edge. By keeping the pressure in the furnace constant at 3 in. of mercury, and keeping the hole *H* clean, a constant quantity of gas will pass through the device per minute. By holding the temperature of the gas and the block constant for 4 min., catching the deposit for that length of time in the tray *J* and in the chamber *c*, this deposit could be accurately weighed and compared to the deposit from a similar unit quantity of gas at any other temperature.

The results showed that at the lower temperatures comparatively large amounts of tar are deposited, as would be expected. This tar is soft and sticky at room temperature, and contains considerable water. As the temperature of the deposit is raised, the amount of the deposit is continuously decreased, and the tar when cooled to room temperature becomes harder and more brittle. All of the tar is thin and liquid at the temperature at which it is deposited, so that so long as the deposit is a tar, the block *G* tends to have only a thin coat on it, the larger part of the deposit appearing in the paper tray. After a while a temperature is reached at which the deposit, though still a tar, is almost too little to be weighed. This temperature of small deposit starts at about 280 or 300 deg. cent. and extends up to about 500 deg. At no point is there a place where the deposit entirely disappears. At about 500 deg. the deposit begins to turn over from a tar to a sort of coke, and instead of being fluid, it all sticks to the block. Between 500 and 600 deg. this deposit increases slowly in amount, and then increases more rapidly as the temperature nears 700 deg.

The condition where the gas and block are at the same temperature is the only one which has been worked out carefully. The best temperature at which to recirculate the tar-laden gas seems to be between about 300 deg. and 450 deg. cent. At any point within this range the deposit of tar is small, and such as there is tends to flow off from the surface of the blower. At temperatures higher than 450 deg. cent. there



FIGS. 4 AND 5 DETAILS OF TAR TESTER

is a chance that the deposit will accumulate on the walls of the blower, and stop it up.

Experience has shown that a heavily tar-laden gas in passing through a cold bed of coal will deposit its tar in the coal until the whole layer of coal becomes impervious to the gas. This state of affairs would be disastrous to the operation of a gas producer. For this reason it becomes interesting to know the lowest temperature at which one may be assured that such a thing will not happen. The tests just reported answer this question as well. If the coal is above 280 deg. cent. this deposit cannot occur.

The results obtained in these special lines of investigation have a direct bearing on the problem of developing a gas producer of the recirculating type for the use of a bituminous fuel. The more important conclusions may be summarized as follows:

a The type of steam exhauster shown in Fig. 2 is efficient and reliable, and is probably the best to use in connection with a gas producer

b The recirculated gas and the pipes through which it passes should be kept between 550 deg. and 900 deg. fahr. in temperature

c The coal at the top of the fuel column should be kept above 550 deg. fahr

d The lowest temperature at which one may be certain that the last trace of tar has been driven off from the coal will vary with the coal used, but will lie between 1000 deg. and 1250 deg. fahr.

Any producer for the use of bituminous fuel should meet all of the requirements which an anthracite plant must meet, and some others. It is difficult to list all, but the following are among the more important:

a The plant must be simple in construction, and must wear well

b All parts of the fuel column must be readily reached by the poker

c A ready means must be provided for cleaning out the clinker and ash

d The air must enter evenly over the entire area of the bottom of the fuel column

e The steam must be evenly distributed through the air for combustion

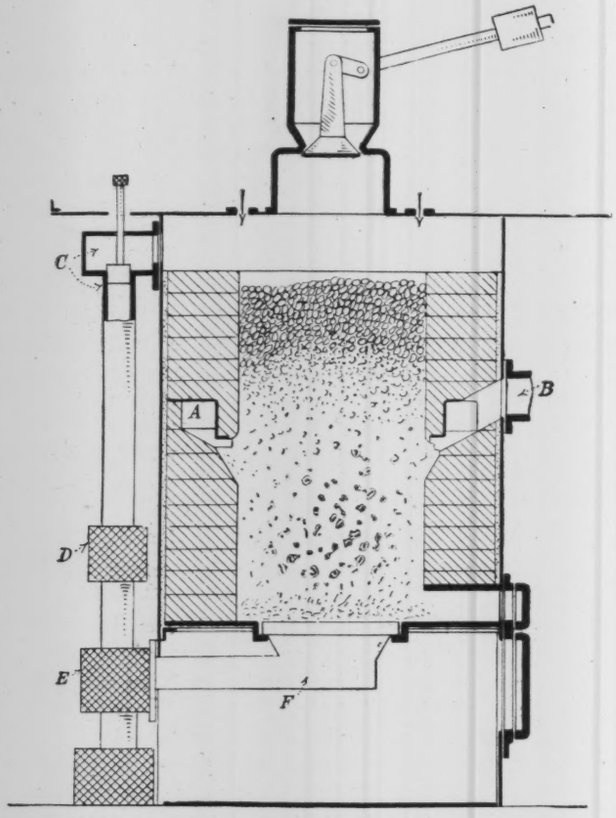


FIG. 6 EXPERIMENTAL PRODUCER IN PURDUE LABORATORY

f The air must be equally free to circulate in all parts of the fuel column

g The gas must be so taken from the producer as to cause an even circulation through the upper part of the fuel column.

PRODUCER DEVELOPED BY AUTHOR

With these points in mind, the author has developed the recirculating gas producer[1] shown in Fig. 6. The coal is trapped in at the top, the only air inlet being below the grates. The combustion all takes place right above the grates. The finished gas is drawn off from the fuel column into the annular chamber *A*, which is formed in the firebrick lining of the producer. From here it passes out through the pipe *B*. The products of distillation and the other recirculated gases are drawn into the pipe *C* by the steam blower *D*. These gases are then delivered into the header *E*, and from there into the distributor *F*. This distributor is so constructed as to deliver an equal amount of the recirculated gases to every part of the grate area, and in such a way that the gas burns as it mixes with the air, largely in the lower part of the combustion zone of the fuel. The recirculated gases burn to CO_2 and H_2O, and in passing through the incandescent zone above, the CO_2, taking up one more carbon atom, is changed into CO, according to the equation

$$CO_2 + C + \text{heat} = 2CO$$

and the H_2O is split up into free H_2 and CO, according to the equation

$$H_2O + C + \text{heat} = H_2 + CO$$

Thus the finished gas obtained from the tars and the other hydrocarbons is the same as that from anthracite coal, and instead of being wasted the tars are converted into useful gas. The gas from this producer should therefore be free from the fluctuating hydrocarbon content that has been the source of so much inconvenience in connection with the gas from most bituminous plants.

Fig. 7 is from a photograph of a 50-h.p. installation of this producer in the laboratories of Purdue University, at Lafayette, Ind., for experimental purposes. Peep-holes *A* are provided to enable the operator to examine the temperature of the fuel column. In the hottest part, where the temperature changes are the most important, this is especially easy. A tube with a rod inside of it may be thrust into the center of the producer, and the rod removed. By looking through the tube the temperature of the fuel at the end of the tube may be estimated. By drawing the tube out slowly and watching the temperature at its end, comparatively slight differences in temperature between the outside and the center of the fuel column may be detected. This is often of great importance in interpreting producer performance. These peep-holes are drilled through the shell and tapped ¾-in. pipe size. Nipples 6 in. long are screwed into these holes, and are capped on their outer ends by standard unions with glass packed in them. The small outlets shown at the sides of many of the ¾-in. pipes are used to draw off samples of the gas to be tested for tar.

The trap *B* is filled with water and catches any tar that may be thrown down in the steam blowers or the recirculating pipes. The header *C* communicates with the gas-distributing device under the grates. The steam blowers *D* and the recirculating pipes are in duplicate, one being used and one held in reserve. The gas from this plant is cooled in a coke-filled scrubber. From this scrubber the gas goes directly to a 43-h.p. Fairbanks-Morse engine.

Returning again to a consideration of the factors influencing the proper performance of this type of producer, if three things are accomplished the gas will be free from tar:

a All of the tar must be driven out of the fuel while it is still above the openings which communicate with the annular chamber.

b All of the tarry vapors driven out of the fuel in the distillation zone must be drawn out and recirculated.

c The recirculated gas must not be allowed to form a cold path for itself between the grates and the outlet on the one hand, nor form an explosive mixture with the entering air on the other. The former would allow the tars to get into the finished gas, and the latter would cause explosions which might prove serious.

It is possible to accomplish these three things continuously

[1] Patented.

and certainly, and to get a gas from a heavily tar-laden fuel which is entirely free from tar.

Inability to meet the first requirement has been the cause of failure of several recirculating producers. Coal is a poor conductor of heat, and little heat can pass by conduction from one lump of coal to another. The heat distribution in the fuel column of a standard up-draft plant is due to the hot gases from the incandescent zone that pass up through the entire fuel column on the way out. In the recirculating producer, the finished gas is drawn out of the fuel column at about mid-height. If the only gases that pass through the fuel above this point are the products of distillation, the heat-carrying medium will be absent above the annular chamber, and the coal will remain cold until after it passes this point. This means that the first requirement has not been met and the producer will not be able to furnish a tar-free gas.

To overcome this a blower of sufficient capacity must be used to recirculate a considerable part of the hot gases from the incandescent zone along with the products of distillation. It is thereby possible to maintain as high temperatures in the fuel column at the top of a recirculating producer as in the up-draft producer, and the coal may be heated until the last trace of tar has been driven off before it reaches the gas discharge level.

This positive stream of gas passing from the bottom of the producer to the top past the annular chamber also enables the producer to meet the second requirement, as it will prevent any of the products of distillation that are driven off from the coal above the discharge level from backing up and passing out at the discharge.

On the third requirement is where many recirculating producers have failed. The gases from any given point in the grate area will tend to establish their own individual path between the grates and the outlet. If they are inert, or do not mix with air and burn in the combustion zone, or, mixed with air, do not burn the coal in the combustion zone, they will not have any heat of combustion with which to establish an incandescent zone. They will therefore form a cold path for themselves right through the zone that should be incandescent, and escape through the discharge outlet unburned and uncracked. To avoid this, the recirculated gases must be evenly distributed over the entire grate area.

To prevent the formation of an explosive mixture, the gases and air must burn as they mix. In this producer this is accomplished by having the gas introduced into the air in the restricted area between the grates, thus preventing them from backing up and mixing with the air below the grates.

The down-draft producer and the double-combustion-zone producer, while both successful in delivering a tar-free gas, have certain shortcomings. The down-draft producer is open to the following criticisms:

a The ash contains a high per cent of the carbon in the coal

b A large part of the tars are cracked in a reducing atmosphere, and consequently produce large quantities of lampblack

c The fuel column is subject to the formation of hard clinkers

d A large proportion of the total heat value of the coal burned is lost in the sensible heat of the gases leaving the producer

e Some types of the down-draft producer cannot be cleaned while running, but must be shut down every week or ten days to have the fire pulled. This is a disagreeable task, besides making it necessary to have two plants.

The double-combustion-zone producer gets around the first and fifth difficulties without adding any serious new ones, but is an equally bad offender in the other three.

The high proportion of total carbon in the coal lost in the ash is characteristic of all down-draft producers. The older types that could not be cleaned while running obviously lose considerable of the carbon when the fire is pulled. In the newer types that are capable of continuous operation, the high carbon in the ash may be explained in that the combustion takes place at the top of the fuel column, but all of the carbon cannot be burned out of the fuel here, as about half of it must be left to reduce the CO_2 in the incandescent zone. This reduction in the incandescent zone is due not only to the high temperatures there, but also to the presence of a large excess

FIG. 7 PHOTOGRAPHIC VIEW OF INSTALLATION OF PRODUCER SHOWN IN FIG. 6

of carbon. Therefore all the carbon cannot be burned out of the fuel in the incandescent zone and have the gas reasonably low in CO_2.

When the tarry vapors are heated to a high temperature in an oxidizing atmosphere they burn, and no lampblack is formed. If, however, the heating takes place in a reducing atmosphere, combustion is impossible, and the tars will be cracked and large quantities of lampblack formed. In both the down-draft producer and the double-combustion-zone producer, the higher-temperature tars from the central part of each lump of coal are inevitably driven off in the incandescent zone. Hence, the ever-present lampblack in the gases from these producers.

All of the causes leading to hard clinkers do not seem to

be understood. It seems, however, that clinkering will be augmented by concentrating the ash in the hottest part of the fuel bed, by stirring or poking this part of the fire, and by the existence of lampblack in the fuel. In both of these types of producers the coal is about half burned at the top of the fire, and is as nearly completely burned as it ever gets to be while it still remains in the incandescent zone. In other words, the coal at the bottom of the incandescent zone is nearly all ash. This incandescent ash is mixed with lampblack, and is frequently and more or less vigorously poked.

The reports of the work done by the United States Geological Survey, in its experiments with gas producers furnish much valuable information. In some cases they give the heat value of the coal, the number of cubic feet of gas obtained from one pound of the coal and the chemical analysis of the gas. Knowing the chemical analysis of the gas, a close estimate can be made of the quantity of undecomposed water that accompanied the gas as it left the producer. The specific heats of all of these gases are quite accurately known. From these figures the per cent of the total heat value of the coal that appears as sensible heat in the hot gases leaving the producer will be nearly equal to the number of hundreds of degrees fahrenheit of temperature of the gases. In other words, gases having the fuel column at 2200 deg. are carrying away about 22 per cent of the total heat value of the coal. But to get a good reduction of the CO_2, it is necessary to have a temperature of at least 2200 deg. fahr. in the incandescent zone of the producer. In the down-draft and the double-combustion-zone producers, the loss due to the sensible heat of the gases as they leave will be above 20 per cent of the total heat value of the fuel used.

In the recirculating producer here proposed, all five of these difficulties are met without introducing any new ones of comparable gravity:

a The combustion takes place as in a standard up-draft anthracite plant. The air all comes from underneath and passes through the ash before reaching the fuel. The last trace of carbon in the hot ash at the bottom of the combustion zone is exposed to the pure air which supports the combustion, so all of it should be burned up. In either the anthracite plant or the recirculating plant the quantity of carbon in the ash is due largely to the care with which the fire has been tended, and should be small.

b All of the tarry vapors are burned in a highly oxidizing atmosphere, so no lampblack is formed

c The fuel being burned after it has passed through the incandescent zone, as it is in the standard anthracite plant, much of the tendency to clinker is avoided. No worse clinkers are produced in this plant than in the anthracite producer; and with proper care and a good coal they can be avoided entirely

d The temperature necessary to eliminate the tar in the coal is never more than 1250 deg. fahr. The gases will have to leave the producer at a temperature somewhat higher than this, say at 1500 to 1600 deg. Still considerably less is lost in the sensible heat in the gas

e The ash can be removed from the producer while it is in operation, and the plant is capable of continuous operation, the length of the run being limited only by the life of the fire-brick lining.

Thus far the author has not been able to carry out long and exhaustive tests on this plant, and regrets his inability to quote figures showing its performance. The best report that can be made is that the plant has run all day (10 hours) each day for a week without making any tar. The heat value and chemical analysis of the gas were not obtained.

THE COMMERCIAL SAMPLING AND ANALYSIS OF PRODUCER GAS

BY PHILIP W. SWAIN, NEW HAVEN, CONN.
Junior-Member

AN analysis of producer gas is ordinarily considered complete if carbon dioxide, oxygen, illuminants, carbon monoxide, hydrogen, methane and nitrogen (by difference) are determined. The quantities of other gases present are almost always negligible, and of illuminants and oxygen usually so small as to make their determination unimportant.

The quality of the gas may usually be judged from the carbon dioxide alone. Low carbon dioxide almost invariably means gas of high heating value and good producer efficiency. The determination of the carbon dioxide can be quickly, easily and accurately carried out with a simple and inexpensive portable apparatus. The ordinary Orsat apparatus or some modification of it may be used, or, if the gas is properly cleaned, some form of automatic recording carbon dioxide machine. The latter, however, at present are expensive and require expert attention to keep them in order. The chief objection to carbon dioxide as a gas quality indicator is that long-period samples collected over water suffer considerable change in carbon dioxide content by absorption or evolution of that gas by the water.

Some plants use the per cent of carbon monoxide in the gas as the basis of a bonus system for producer operators. The carbon monoxide is not appreciably affected by water, so that long-period continuous samples can be taken. Although this element furnishes the greater part of the heat in the gas, high carbon monoxide might be produced at the expense of hydrogen by changing the ratio of steam to air in the blast. If this is taken into account or controlled, the carbon monoxide should give a good indication of the quality of the gas.

To make rapid and accurate determinations of carbon monoxide the apparatus should have two bubbling pipettes, containing the regular cuprous chloride solution which is used for this purpose. One of these solutions should be kept quite fresh and be used to absorb the last trace of carbon monoxide after the other has absorbed most of it.

Before long it will probably be the practice to determine gas quality by some form of recording calorimeter. Such instruments have been used for years, and often have proved very useful. In general, however, they require frequent adjustment if absolute rather than merely relative values are desired. This difficulty will doubtless be overcome in time.

A rather crude but ideally simple way of estimating the quality of gas almost universally used is a test flame left constantly burning. By its use the producer operator can detect large variations in the gas quality.

SAMPLING

The sample of gas may be drawn directly from the gas main or from a pipe through which fresh gas continuously flows, such as that which supplies the test flame. For a continuous sample the pressure in the pipe should be practically constant where the sample is taken. Any variation increases or decreases the flow of gas into the sampling bottle

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

even when the flow of water from the bottle is properly regulated. The sampling connection will be at practically atmospheric pressure if it is on the test-flame pipe beyond the valve that regulates the flame.

If there is no gas main with a pressure above atmospheric, some form of steam aspirator[1] can be used to produce a steady flow of gas from the main. The rate of flow should be such that the gas in the aspirator pipe will always be substantially the same as that in the main.

The proper form and position of the sampling pipe in the gas main has received a great deal of attention. The writer believes that, if the gas is sampled after passing through the scrubber, it is so thoroughly mixed that an open-end sampling tube at the center of the main will draw a representative sample. In fuel-gas installations where the gas is not washed the mixture of the gas in the main is much less complete, but special sampling tubes with small holes would be so likely to become clogged if used with unwashed gases that the open-end sampling tube would be better, placing it as far as possible from the producer to insure the maximum amount of mixing.

Of the several ways for drawing the sample, probably the most common is the so-called "two-bottle method." Two large bottles have openings near the bottom connected by a long rubber tube. The bottle for collecting the gas has a rubber stopper through which passes a glass tube connected to the sampling pipe by a rubber tube. The bottle are partly filled with water, which admits gas to or expels it from the sampling bottle when the second bottle is lowered or raised. Before taking a sample a charge of gas is drawn and shaken up with the water to saturate it and thereby reduce its effect on the sample. The water is then forced to the top of the sampling bottle and the rubber tube connecting the bottles closed with a pinch cock. Then the second bottle is placed some distance below the other and the pinch cock opened to let the water flow from the sampling bottle.

When continuous samples extending over long periods are taken, using the ordinary two-bottle method, a number of errors occur aside from that due to the absorption and evolution of carbon dioxide by the water. If the rate of sampling is not proportional to the flow of gas in the main and the gas composition varies widely, a considerable error may result.

Two reasons why the flow of water—and hence the rate of sampling—varies are that the restricted opening in the compressed rubber tube tends to clog and that the net head producing the flow of water, which is the difference in level in the water surfaces of the two bottles, is constantly decreasing as the water flows from the upper to the lower bottle.

It is evident that the ordinary two-bottle method never gives an exactly correct sample, and that clogging of the thin tapering opening in the rubber tube may produce a large error without being detected.

Fig. 1 shows an arrangement that the writer has devised for easily measuring and controlling the rate of sampling. The upper bottle is connected as in the ordinary two-bottle method, but the water passes into the top of the lower bottle through a simple form of orifice flow meter. This meter is constructed largely of ⅛-in. brass pipe fittings. A thin copper disk with a small orifice is clamped between the two halves of the union so that the head of water which is producing the flow through this orifice can be measured on the manometer shown at the left of the union. A small opening in the top of the elbow shown on the right prevents the nipple below from acting as a tail pipe to increase the head on the orifice. The orifice, being made in a very thin plate, gives little trouble from clogging if clean water is used; however, a small cloth filter can be inserted in the nipple at the left of the tee. The iron fittings in the neck of the lower bottle serve merely as a support, and may be replaced by a stopper with two holes, one to admit the ⅛-in. nipple and the other to act as a vent. A series of orifices for various rates of flow may be prepared by piercing disks of copper foil with needles and smoothing off the rough edges on an oil stone.

For sampling at a uniform rate the water in the manometer tube can be kept to any mark by an occasional adjustment of the pinch cock on the rubber tube. To take a continuous proportional sample it is necessary to have a flow meter in the gas main and scale of rate of flow on the manometer. Since it is only necessary that the rate of flow of the water be

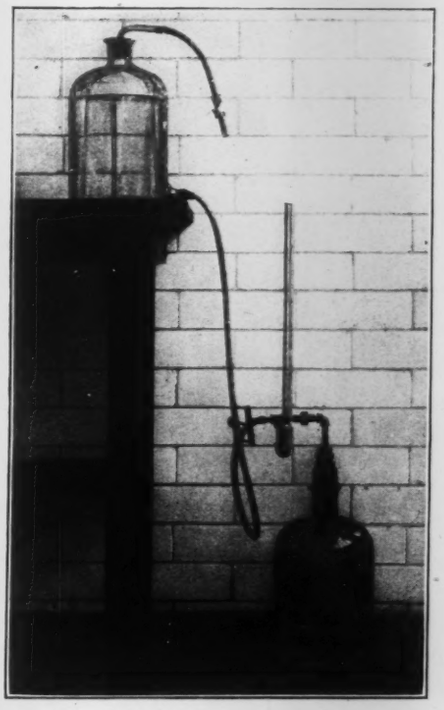


FIG. 1 APPARATUS FOR PROPORTIONAL SAMPLING

proportional to the rate of flow of the gas in the main, it is immaterial what units of flow are used. Four scales of flow are used by the writer chosen so that it is usually possible to pick one whose graduations (without regard to the decimal point) more than cover the probable range of readings of the flow meter on the gas main.

A test to determine the accuracy of this flow showed a maximum variation of 2 per cent from the mean.

GAS ANALYSIS

The engineer testing or operating gas producers usually desires a portable gas analyzer that is rapid, reliable and easy to operate and will give each constituent correctly within 0.2 or 0.3 per cent of the total volume of gas.

In the Orsat apparatus used to analyze furnace flue gases the pipettes for absorbing the components usually contain the following reagents: for carbon dioxide either caustic pot-

[1] For a description of such an aspirator, see Bulletin No. 97 of the Bureau of Mines on "Sampling and Analyzing Flue Gases."

ash or caustic soda, for oxygen either an alkaline pyrogallol solution or sticks of phosphorus (in water), and for carbon monoxide either an acid or an ammoniacal solution of cuprous chloride.

The absorption of carbon dioxide by either the caustic potash or caustic soda solution is rapid and the solutions have a large absorbing capacity so that frequent changes are not necessary. The alkaline pyrogallol solution for oxygen is slower in its action and has a smaller absorbing capacity. The solution must be carefully protected from air by a rubber bulb, and tends to give off carbon monoxide if old or improperly prepared.

Phosphorus sticks ordinarily make an ideal reagent for absorbing oxygen. The presence of 0.1 cc. of oxygen will produce fumes that are easily visible, and the reaction once started

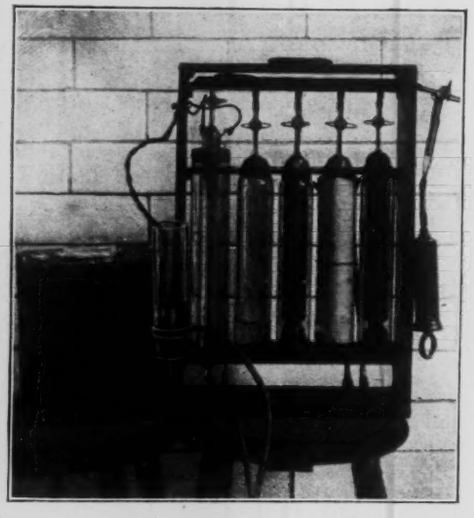


FIG. 2 WILLIAMS APPARATUS FOR PRODUCER GAS ANALYSIS

is always complete in a minute or two if a large surface of yellow phosphorus is exposed. Presence of a small quantity of ethylene completely prevents the reaction between phosphorus and oxygen, so phosphorus should not be used for producer gas that contains ethylene unless the ethylene can be absorbed before the oxygen. If the slightest fumes are visible it is known that the phosphorus is acting properly, and almost any producer gas will contain enough oxygen to produce visible fumes. The sticks gradually turn dark and become inactive if exposed to the sunlight, so that the pipette should be wrapped with dark paper. With this precaution one set of phosphorus sticks can be used for years without any attention.

The carbon monoxide is the least satisfactory to absorb of the three gases. The cuprous chloride solution acts slowly, has a small absorbing capacity and is unreliable unless quite fresh, for there is no way of telling when the absorption is complete. It is impossible to absorb all of the carbon monoxide with a solution that has already taken up considerable of the gas. With the producer gas a fairly complete absorption of the carbon monoxide can be made by using two pipettes, the second to take out only the remnant left by the first.

Some of the newer types of Orsat apparatus are arranged so that the gases can be bubbled through the reagents. This greatly reduces the time required for absorbing all the gases, particularly the carbon monoxide. With phosphorus nothing is gained by using a bubbling pipette, as the reagent is a solid.

The ordinary Orsat apparatus is not sufficient to completely analyze producer gas. Provision must be made for determining hydrogen, methane and illuminants (chiefly ethylene).

The Williams apparatus, shown in Fig. 2, is one of several portable instruments now on the market similar to the Orsat. Bubbling pipettes are used for all of the liquid reagents. From left to right, the pipettes shown contain caustic soda solution for carbon dioxide; bromine water for illuminants; phosphorus sticks for oxygen, and an acid cuprous chloride solution (containing copper strips) for carbon monoxide. Since there are only four pipettes, a second cuprous chloride pipette could only be obtained by omitting the bromine water for illuminants. If this is done a pyrogallol solution should be used instead of the phosphorus, because the gas might contain a little ethylene.

In the ordinary method of operation the carbon dioxide, illuminants, oxygen and carbon monoxide are absorbed in this order and the hydrogen and methane are then determined by explosion with air in the explosion burette. It is necessary to use a slight excess of air and to measure the contraction on explosion and the carbon dioxide produced by the explosion. The latter is determined by absorption in the first

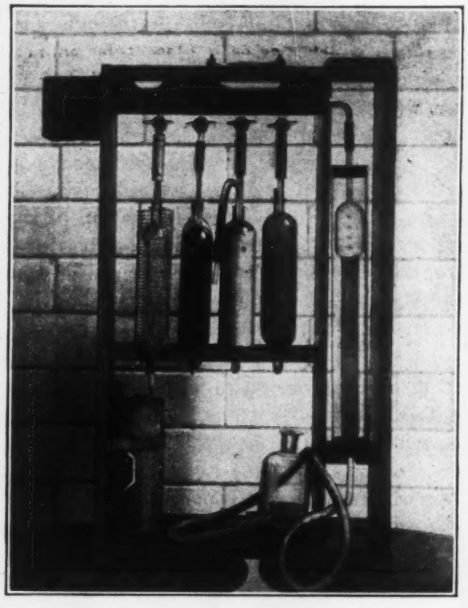


FIG. 4 ORSAT APPARATUS WITH EXPLOSION PIPETTE

pipette. If the full amount of gas left after the absorption of carbon monoxide is used for the explosion, the following equations are employed:

methane = carbon dioxide produced

hydrogen = 2/3 contraction − 4/3 carbon dioxide produced

The method just described is the usual one for the analysis of producer gas with a portable apparatus, but it has certain disadvantages, as follows:

a On account of the large amount of carbon monoxide in producer gas the cuprous chloride solution must be changed very often, with consequent trouble and expense.

b As the amount of methane present is small it may easily happen that the hydrogen content of the gas may be so slow that the gas will not explode with air. In this case it becomes impossible to determine the hydrogen and methane by the ordinary method.

Instead of absorbing the carbon monoxide it may be determined with the hydrogen and methane by one explosion. This does away with the troublesome cuprous chloride solution and insures an explosion if the gas is combustible. This, however, requires the determination of the oxygen consumed as well as the contraction and the carbon dioxide produced. The absorption of the oxygen left over from the explosion is quicker than the absorption of carbon monoxide. On the other hand, the computations required are somewhat more extensive, but this work can be greatly simplified, as will be shown later.

gas it is sufficient to use 124 cc. of air (26.0 cc. oxygen). With this quantity of air the explosive mixture would make more than 200 cc. and could not be contained in the burette so the volume of gas must be reduced before explosion. To simplify the calculation it is well to throw away exactly one-half of the volume of gas remaining after absorbing the carbon dioxide, illuminants and oxygen and then to take in 62 cc. of air containing 13.0 cc. of oxygen. If one-half of the gas is used for the explosion the following equations give the percentage of hydrogen, carbon monoxide and methane in the original gas:

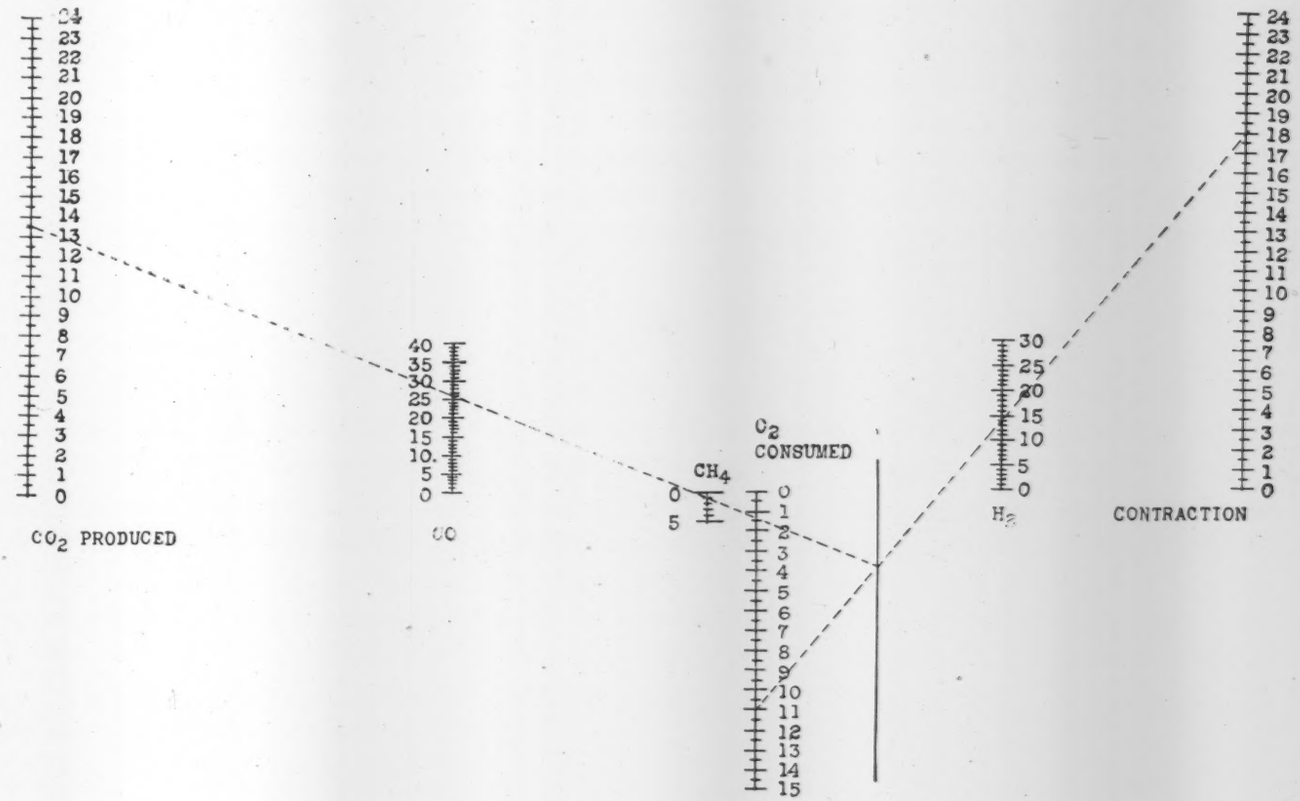


FIG. 3 DIAGRAM FOR DETERMINING HYDROGEN, CARBON MONOXIDE, AND METHANE

The burette of the Williams machine is graduated like that of an ordinary Orsat with the zero where the volume is 100 cc. and the 100 mark at the top. This is the best arrangement where only absorption determinations are made, but is somewhat confusing when making a complete analysis. The instrument shown in Fig. 2 has been provided with another scale on the left, which gives the volume directly. Moreover, the graduations have been extended nearly to the bottom of the burette so that a volume up to 115 cc. may be measured. This provides for the increased amount of air which must be used when the carbon monoxide is left in the gas which is to be exploded.

In the determination of carbon monoxide, hydrogen and methane by one explosion it is necessary to measure the oxygen consumed in the explosion as well as the contraction and carbon dioxide produced.

The first two are determined as in the ordinary method where only the hydrogen and the methane are exploded. To determine the quantity of oxygen consumed the air taken in must be measured and the excess of oxygen determined by the phosphorus pipette. For 100 cc. of ordinary producer

Hydrogen = 2 (contraction — oxygen consumed)

Carbon monoxide = 2 (1/3 contraction + 4/3 carbon dioxide produced — oxygen consumed)

Methane = 2 (oxygen consumed — 1/3 contraction — 1/3 carbon dioxide produced)

To solve these equations quickly for routine analyses the diagram Fig. 3 may be used. The dotted lines show the method of using the diagram, but in ordinary solutions no lines need be drawn if use is made of a celluloid straight edge and a fine needle. The manipulation might be as follows:

a Place needle at contraction.
b Swing straight edge around needle to the oxygen consumed.
c Read hydrogen.
d Place needle at intersection of straight edge and blank.
e Swing straight edge around needle to carbon dioxide produced.
f Read carbon monoxide.
g Read methane.

This method of reading the diagram is rapid and accurate. More accurate readings can be made if a larger diagram is used.

The data and results of the analysis may be conveniently recorded on a form similar to the following (readings on true volume scale):

a.	Take 100 c.c. of gas,	absorb carbon dioxide.....	reading	.....
b.	.....	absorb illuminants.....	reading	.....
c.	.....	absorb oxygen.....	reading	.....
d.	Throw away one half of remaining volume.....		reading	.....
e.	Take in 62 cc. of air (13 cc. of oxygen).....		reading	.....
f.	Explode.....		reading	.....
g.	Absorb carbon dioxide produced.....		reading	.....
h.	Absorb oxygen left over.....		reading	.....
i.	Contraction due to explosion.....		(e — f)	.....
j.	Carbon dioxide produced by explosion.....		(f — g)	.....
k.	Oxygen consumed in explosion.....		[13-(g — h)]	.....
		Carbon dioxide.....	(100—a)	.....
		Illuminants.....	(a — b)	.....
		Oxygen.....	(b — c)	.....
		Hydrogen.....	(diagram)	.....
		Carbon monoxide.....	(diagram)	.....
		Methane.....	(diagram)	.....

Producer gas is often free from illuminants, so that time may be saved by passing directly to the phosphorus pipette after the carbon dioxide has been determined. If any fumes appear the absorption of oxygen can be continued. In this case the same reading is recorded at *b* as appears at *a*. If fumes do not appear the gas is passed into the pipette containing bromine water and then into the carbon dioxide pipette to absorb the bromine fumes. The action is rapid, so that one pass through each pipette is sufficient.

If the analysis is made with the explosion of hydrogen and methane only, the following form may be used for the data and results:

a.	Take 100 cc. of gas,	absorb carbon dioxide.....	reading	.....
b.	.....	absorb illuminants.....	reading	.....
c.	.....	absorb oxygen.....	reading	.....
d.	.....	absorb carbon monoxide....	reading	.....
e.	Throw away one half of remaining volume.....		reading	.....
f.	Take in an excess of air.....		reading	.....
g.	Explode.....		reading	.....
h.	Absorb carbon dioxide produced.....		reading	.....
i.	Contraction due to explosion.....		(f — g)	.....
j.	Carbon dioxide produced by explosion.....		(g —h)	.....
		Carbon dioxide.....	(100—a)	.....
		Illuminants.....	(a —b)	.....
		Oxygen.....	(b — c)	.....
		Carbon Monoxide.....	(c — d)	.....
		Hydrogen.....	(4/3 i—8/3 j)	.....
		Methane.....	(2j)	.....

Fig. 4 shows an ordinary Orsat apparatus modified for analyzing producer gas. From right to left, the first three pipettes contain caustic potash solution, phosphorus and bromine water. The fourth pipette is arranged for explosion through a heated platinum wire. Using a heated wire instead of a spark gap eliminates the induction coil, so that the apparatus is self-contained. The copper leads pass down through a glass tube. This tube has an explosion-tight joint, but can be easily removed or replaced if necessary. The results obtained are as accurate as with the Williams apparatus, but more time is required for an analysis on account of the type of burette and pipettes employed.

A professorship in aeronautics has been established in the division of mechanical engineering at the University of Illinois. Elisha N. Fales, of Buffalo, N. Y., has been appointed Assistant Professor of Aeronautics.

During the first year Mr. Fales will present only general introductory courses on the subject, but a more elaborate program will be offered next year. For the present the instruction will be open to senior students in the College of Engineering.

There are some forty students in his class. The University is now trying to get a flying station of the War Department located on University grounds, and also get an equipment which will enable it to do something in a really scientific way. (From a letter of Dr. Edmund J. James, President, University of Illinois.)

———

A most glaring example of the lack of knowledge regarding screw-thread fits comes from a maker of munitions who is supplying a nation that is well known for the excellence of its mechanical lines. The product turned out by this manufacturer had a number of screw-thread fits, one in particular being very carefully gaged. It so happened that a large number of these parts got by the factory inspector with the outside diameter a mere trifle under size. The pitch diameter was practically perfect. They fitted a threaded ring gage satisfactorily, but the outside snap gage, which should not have been used at all, showed the work to be slightly under size.

In vain the maker tried to show the inspector that the fit was perfect, and that for the outside diameter to be exact was practically of little account. "Orders is orders," and the pieces were condemned. But they were not thrown away; not by a long ways. If outside diameter was what they wanted, they should have it.

So a special rolling tool was made, with the lead a trifle off, and the threads were rolled so as to increase the diameter. At the same time it distorted the lead slightly, so that the metal rolled up would not make the piece a loose fit in the ring gage. In this way all the rejected parts were saved—all passing inspection—and yet they were not so good a job as before they were "doctored for the inspector." (*American Machinist,* vol. 45, no. 17, October 26, 1916.)

———

A new non-metallic gear material is a product of heavy duck bonded together with Bakelite by heating while under heavy pressure. It is said to be as strong as cast iron, unaffected by atmospheric changes, vermin-proof, and may be stored indefinitely without shrinkage or other deterioration. It can be operated in oil without any signs of swelling, and is self-supporting, in most cases requiring neither bushes nor flanges. When properly applied and lubricated, it is stated that gears of this material will outlast those made from rawhide or other non-metallic gear materials, and in certain classes of service will outlast cast iron.—*The Electric Journal,* August, 1916.

———

According to a recent issue of *Nature,* a Swedish company has been formed to manufacture ammonium nitrate and other nitrogenous compounds by chemical processes from easily accessible raw materials. It is thought possible that the new system will prove a serious rival to the electrical fixation of nitrogen.

RAILROAD PAPERS

TWO papers on Electric Locomotives and Clasp Brakes, to be presented at the Railroad Session on Friday morning, were published in the November Journal. An abstract of a third paper, on Pulverized Fuel for Locomotives, is given below. Next to labor, the largest item of cost for transportation is the fuel used for locomotives, and the paper sets forth how the use of pulverized fuel will assist in improving railway operation.

PULVERIZED FUEL FOR LOCOMOTIVES

By JOHN E. MUHLFELD, NEW YORK, N. Y.

Member of the Society

AS next to labor the largest single item of cost for transportation is the fuel used in locomotive operation, and as in the final analysis the cost per revenue passenger or per ton mile is largely conditioned upon the capacity, effectiveness and economy of the unit of motive power per hour, it is easy to realize to what extent the credit of a steam railway is controlled by its locomotive performance and expense.

In order to set forth how the use of pulverized fuel will assist in improving steam railway operation, the following facts and conclusions resulting from a number of years of investigation and research and of development work in connection with this most important subject may be of immediate interest.

a The expenditure for locomotive fuel for the steam railways in the United States now approximates $300,000,000 per annum, of which from $75,000,000 to $100,000,000 represents the proportion that is expended to kindle, prepare, clean and maintain fires on grates when locomotives are standing, drifting or otherwise not actually using steam to move themselves, either light or with trains.

b Changes in the domestic and foreign supply and demand, as well as in the regulations, methods and labor governing mining operations, cause a progressive increase in the price per ton of fuel.

c Necessity for conserving the limited supply of oil in the rapidly exhausting fields for other than railway fuel purposes will soon eliminate this fuel from locomotive service; while the higher prices and shortage in supply of the larger sizes and better grades of solid fuels that are in demand for the commercial trade will bring about the use of the less salable general by-product of the mines in pulverized form, by the railways and industries which are adjacent to the mines.

d The extraordinary expenditure required for first cost and fixed charge, as well as for combined maintenance and operation, together with the necessity for reliability and flexibility in motive power, precludes the general use of electricity either from an engineering or an operating standpoint for the movement of heavy traffic over long distances.

e Steam locomotives will be equipped to approximate electric service by the use of pulverized fuel, which in turn will eliminate smoke, soot, cinders, sparks and fire hazards; reduce noise, time for dispatching at terminals, and stand-by losses;

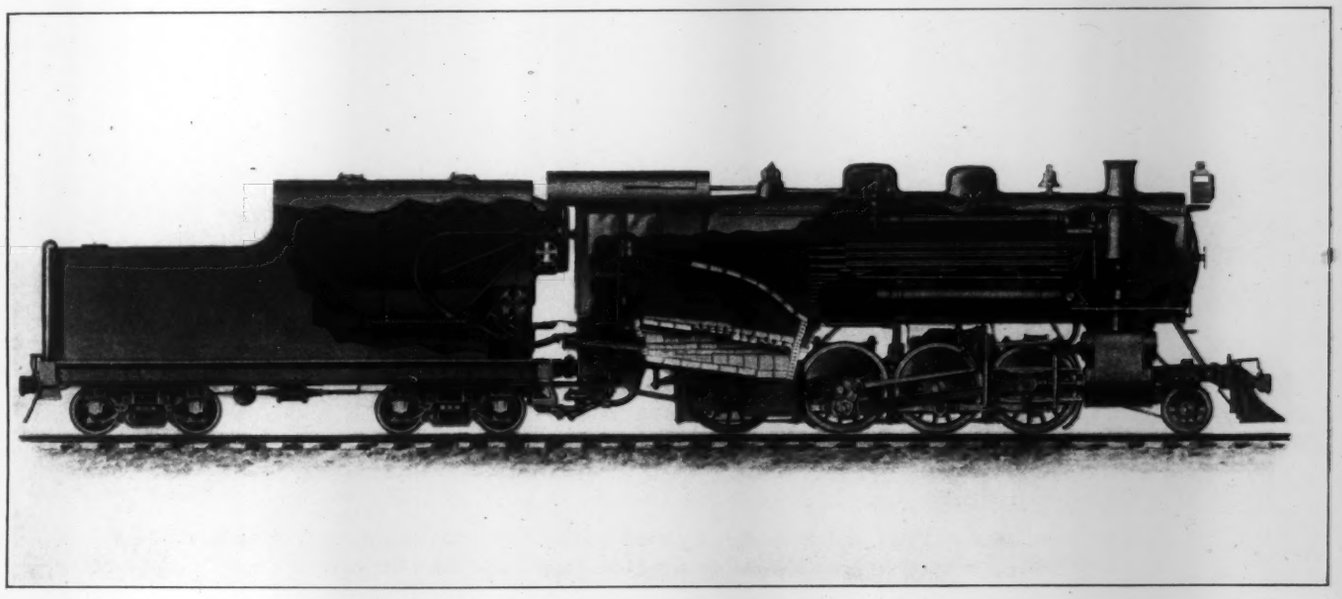


FIG. 1 SECTIONAL VIEW OF LOCOMOTIVE SHOWING PULVERIZED-FUEL-BURNING EQUIPMENT

The fuel in the enclosed fuel tank gravitates to conveyor screws which carry it to the fuel and pressure-air feeders, where it commingles with the air. It is then carried through the connecting hose to nozzles and blown into the fuel and air mixers. Additional air is supplied and the mixture is drawn into the furnace by the smokebox draft. The fuel conveyor, feeder and commingler are driven by a variable-speed turbine. The liquid ash runs down the underside of the main arch and the sides of the furnace and is precipitated into a self-clearing slag pan where it solidifies into a button of slag which can be readily dumped.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

and increase the daily mileage by producing longer runs and more nearly continuous service between general repair periods.

f In order to provide the maximum draw-bar horsepower per hour, the steam locomotive must be so improved as to secure continuity of working steam pressure, greater sustained boiler capacity, increased boiler efficiency, reduced cylinder back pressure, and more highly superheated steam, all of which can be produced by the use of pulverized fuel.

g The large quantity of steam required by the modern locomotive necessitates excessive rates of evaporation, such as can only be effectively and economically produced by the burning of pulverized fuel in suspension in order to utilize the heat units that now go out of the stack and into the ash-pan when solid fuel is fired on grates.

h By mechanically feeding and burning pulverized fuel, arduous labor on the part of the fireman, such as is now required to shovel ahead and supply coarse coal to grates and to rake and clean fires and ash pans, is replaced by the more skilled manual control of combustion and assistance to the engineer in the operation of the locomotive and observation of track and signals.

i The future steam locomotive, on account of its track and bridge weight and tunnel and overhead clearance limitations, will be required to produce the maximum possible hauling capacity per unit of total weight. As the cylinder horsepower available is entirely dependent upon the boiler horsepower and temperature of superheated steam produced, the use of pulverized fuel to increase the heat value per cubic foot of firebox volume and provide a higher average and more uniform firebox temperature in combination with a reduced front-end or waste-heat temperature, appears to be the most logical means for the solution of the problem.

j The opportunity for reducing the non-productive time of existing locomotives and for relieving terminal congestion that is now caused by the necessity for cleaning fires, ash pans, flues, and smokeboxes; inspecting and repairing draft, grate and ash-pan appliances and for firing-up and supplying firing tools and equipment to locomotives burning coal on grates, makes the use of pulverized fuel one of the most effective and economical means for increasing the net earning capacity of present single- and double-track steam roads.

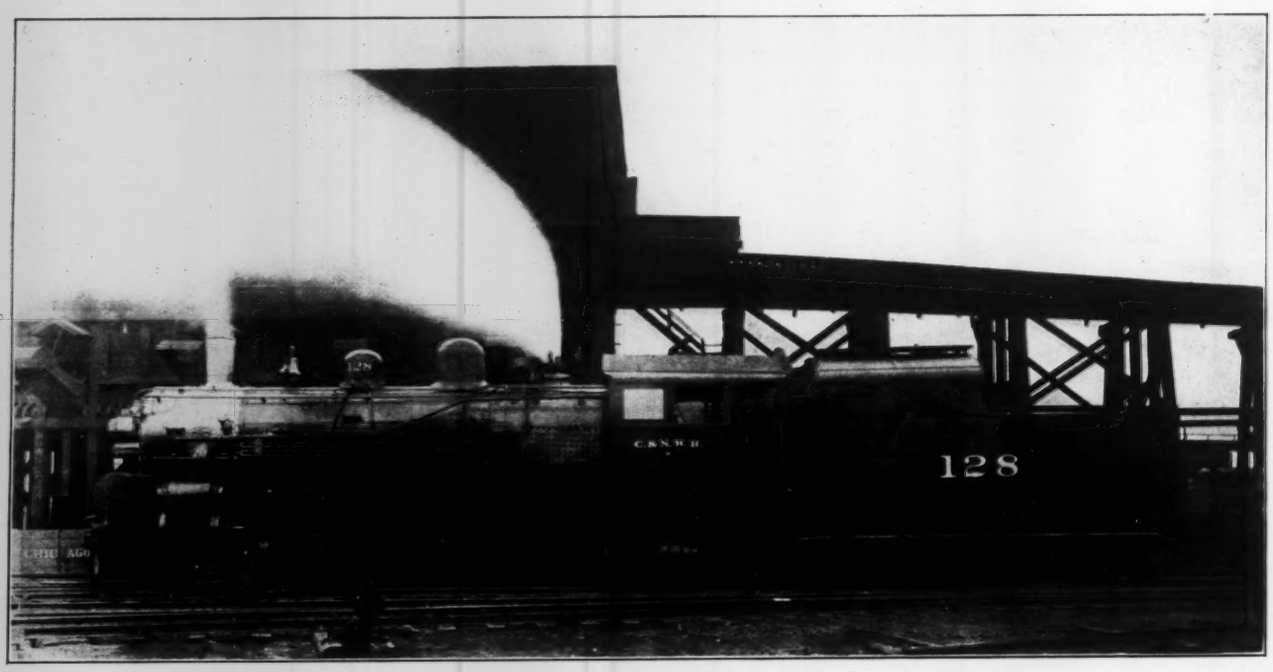


FIG. 2 CHICAGO AND NORTH WESTERN RAILWAY ATLANTIC TYPE PASSENGER LOCOMOTIVE NO. 128, THE FIRST TO BURN PULVERIZED FUEL IN REGULAR FAST-PASSENGER SERVICE

SPECIFICATIONS FOR PULVERIZED FUEL

From investigations to date, any solid fuel that, in a dry, pulverized form, has two-thirds of its content combustible, is suitable for steam-generating purposes.

Domestic and steam sizes and qualities of anthracite, bituminous, and semi-bituminous coals and lignite and peat, as well as the inferior grades, such as anthracite culm, dust and slush, and bituminous and lignite slack, screenings and dust, are all suitable for burning in pulverized form.

To produce the best results these fuels should be mechanically dried and milled so that they will be of about the same dryness and fineness as portland cement; or so that the moisture will not exceed 1 per cent, and that 95 per cent of the total will pass through a 100-mesh screen and 85 per cent of the total will pass through a 200-mesh screen. This applies to anthracite as well as to bituminous coals.

EQUIPMENT AND COST FOR PREPARING PULVERIZED FUEL

As over 8,000,000 tons of pulverized fuel are now being used annually in the United States for industrial kilns and furnaces, it is not thought that the equipment or process for preparing pulverized fuel requires any comment.

The total cost to prepare pulverized fuel properly in a suitably equipped drying and pulverizing plant will range from 15 to 45 cents per ton, depending upon the capacity of the plant. For a railway coaling station of average capacity, this total cost will be less than 25 cents per ton, an item which

will be more than offset by the difference in the cost on the tender of the grades of coal purchased for pulverizing and those that are required for burning satisfactorily on grates.

STORAGE AND HANDLING OF PULVERIZED FUEL

The raw fuel should be dried, pulverized and stored in metal or other fireproof material containers in such quantities as are needed to supply the demand. After pulverizing it should not be exposed to open lights or the atmosphere, and the production of light "dust-clouds" should be avoided.

Pulverized fuel should be handled with the same care as fuel oil.

EQUIPMENT FOR SUPPLYING PULVERIZED FUEL TO TENDERS

This consists of one or more overhead storage bins equipped with suitable means for supplying 15 tons of pulverized fuel to a tender in 3 or 4 minutes without exposing the fuel to the atmosphere during its conveyance, or producing any dust-clouds.

Complete control of the fuel flowing to, and of the air exhausting from, the tender must be maintained, and this can only be done by installing special equipment suitable for the requirements.

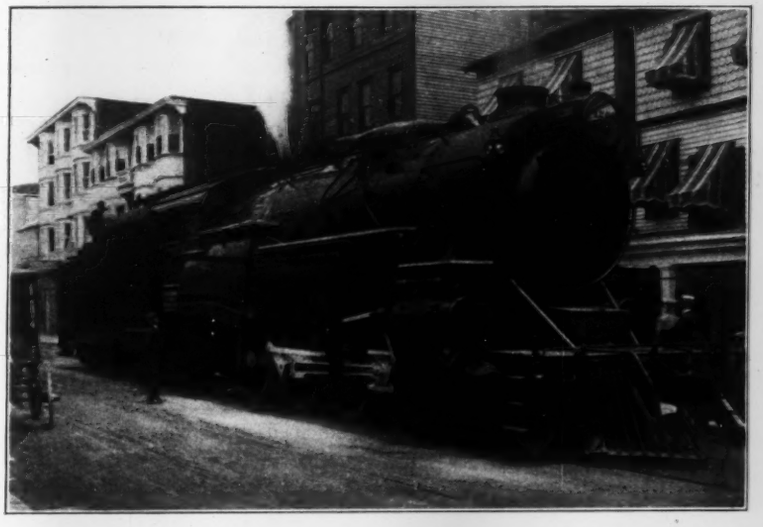


FIG. 3 THE DELAWARE AND HUDSON COMPANY CONSOLIDATION LOCOMOTIVE NO. 1200 STANDING ON EXHIBITION TRACKS AT ATLANTIC CITY, WITH POP VALVES BLOWING AND BURNING AT THE RATE OF 6,000 LB. OF BITUMINOUS COAL PER HOUR

OPERATION OF PULVERIZED-FUEL-BURNING EQUIPMENT

For firing up a locomotive, the usual steam blower is turned on in the stack, a piece of lighted waste is then entered through the firebox-door opening and placed on the furnace floor, just ahead of the primary arch, after which the pressure fan and one of the fuel and pressure-air feeders are started.

From 45 to 60 min. is ordinarily sufficient to get up 200 lb. of steam pressure from boiler water at 40 deg. fahr.

After firing up, the regulation of the fuel and air supply is adjusted to suit the standing, drifting or working conditions, the stack blower being used only when the locomotive is not using steam.

The operation of the fuel-burning equipment is as follows:

The prepared fuel, having been supplied to the enclosed fuel tank, gravitates to the conveyor screws, which carry it to the fuel and pressure-air feeders, where it is thoroughly commingled with the pressure-air and carried by it through the connecting hose to the fuel and pressure-air nozzles and blown into the fuel and air mixers.

Additional induced air is supplied in the fuel and air mixers, and this mixture, now in combustible form, is induced into the furnace by the smokebox draft.

The flame produced at the time the combustible mixture enters the furnace obtains its average maximum temperature (from 2500 to 2900 deg. fahr.) at the forward combustion zone under the main arch, and at this point auxiliary air is induced by the smokebox draft to finally complete the combustion process.

The liquid ash runs down the underside of the main arch and the front and sides of the forward combustion zone of the furnace and is precipitated into the self-clearing slag pan, where it accumulates and is air-cooled and solidified into a button of slag which can be readily dumped.

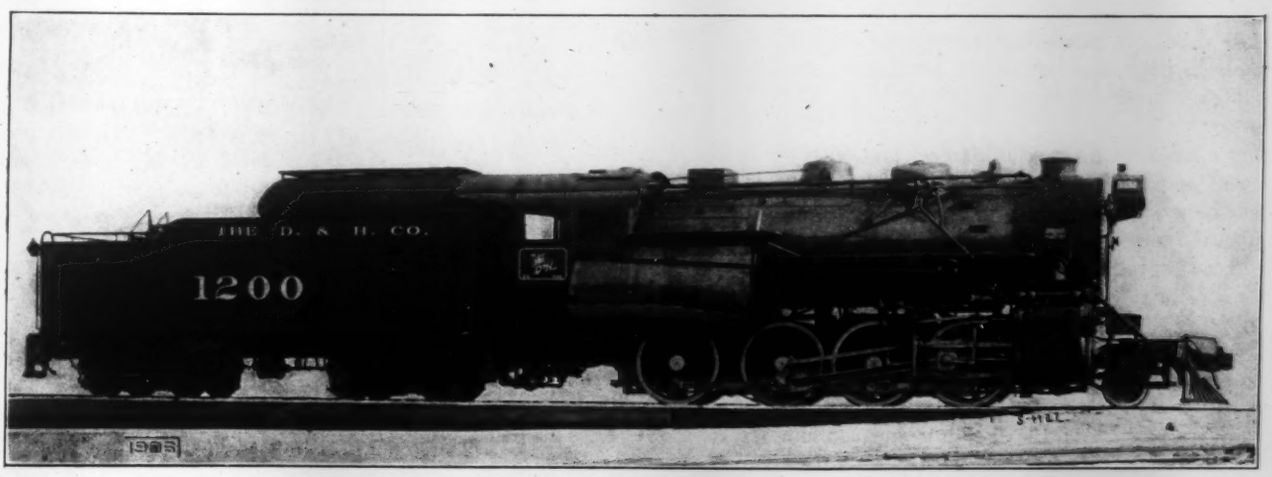


FIG. 4 THE DELAWARE AND HUDSON COMPANY CONSOLIDATION LOCOMOTIVE NO. 1200, THE LARGEST OF ITS TYPE IN THE WORLD, EQUIPPED FOR BURNING PULVERIZED FUEL

FIG. 5 FINAL COMBUSTION CHAMBER AT FRONT OF FIREPAN AND FIREBOX

As each of the fuel and pressure-air feeders has a range in capacity of from 500 to 3000 lb. of pulverized fuel per hour, and as from one to five of these may be easily applied to the ordinary locomotive tender, there is no difficulty in meeting any desired boiler and superheater capacity.

The uniformity with which locomotives can be fired is indicated by the fact that the regularly assigned firemen can maintain the steam within a variation of 2 lb. of the maximum allowable pressure without popping off.

CHEMISTRY OF THE COMBUSTION OF PULVERIZED FUEL

The principal fuels adaptable for use in pulverized form in locomotives are anthracite, semi-anthracite, semi-bituminous and bituminous coals and lignite and peat. (Pulverized-fuel-burning locomotives are also readily convertible for the use of fuel oil.)

Generally speaking, it is necessary to break up any fuel to such uniform size that the oxygen in the air can unite perfectly for combustion. A deficiency in this respect results in some portions of the fuel passing off as unburnt hydrocarbons, and other portions being left as incompletely burned coke. It is equally important that the proper quantity of air should be admitted to the furnace, as any insufficiency or excess lowers the efficiency.

For e ample, the preventable fuel loss with 8 per cent of CO_2 in the stack gases will be about 10 per cent, with 12 per cent of CO_2 it is reduced to about 3 per cent, and with 16 per cent of CO_2 there is practically no waste.

As a 1-in. cube of coal exposes but 6 sq. in. of area for absorbing oxygen and liberating heat, but when pulverized to the proper fineness will expose from 20 to 25 sq. ft. of area for oxidation, the first essential for complete combustion is the breaking up of the fuel into dry, minute and uniform particles. Then by diffusing these so that each may be surrounded with the right quantity of air for complete combustion, it will be possible to burn practically all of the available combustible, regardless of the percentage of non-combustible.

The value of a fuel is determined by the quantity of heat that it will generate when burned, and this in turn is dependent upon how much combustible carbon, hydrogen, hydrocarbons and sulphur and how much non-combustible moisture, ash, oxygen and nitrogen it contains.

Of the non-combustibles, ash, which usually contains a mechanical mixture of silica, alumina, iron, lime, potassium, sodium and magnesium, is the most detrimental. Like moisture, it is anti-calorific, and furthermore it acts as an obstruction to the flow of air and gases, reduces boiler capacity and efficiency, and incurs heavy expense and delays in the cleaning of fires and ash pans and in the final disposition of the ash.

The "clinkering" and "honeycombing" of ash is one of the worst troubles to be contended with in the combustion of coal, and its formation may be either chemical or by fusion.

Clinker is of two kinds, "hard" and "soft."

"Hard clinker" is formed by the direct melting of some of the ash content. It hardens as it forms and usually gives but little trouble.

"Soft clinker" is formed by the slagging of the ash and is either pasty or fluid and steadily grows in size.

"Honeycomb" or "flue-sheet" clinker is formed by the condensation or coking of tarry matter or vapor as it strikes against the firebox sheets, and results in the accumulation of a relatively soft, light, ashy substance that grows or spreads over certain of the refractory or metal parts of the furnace.

With the use of pulverized fuel the usual difficulties resulting from the formation of hard and soft clinker on grates are eliminated, but with fuels containing certain intrinsic combinations of ferrous silicates which fuse at comparatively low temperatures (2000 to 2300 deg. fahr.), the honeycomb formation will result when the proper air supply and combustion conditions do not obtain to produce ferric silicates, which fuse at relatively high temperatures (2500 deg. fahr and above). For example, during the process of combustion ferric sulphide

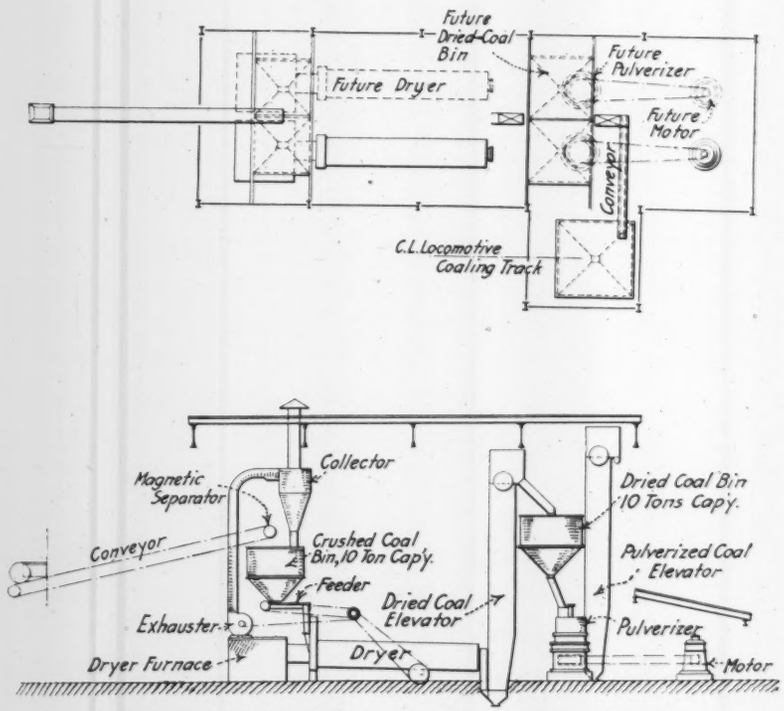


FIG. 6 TYPICAL 8-TON PER HOUR CAPACITY DOUBLE UNIT MILLING PLANT, AND SINGLE BIN LOCOMOTIVE COALING STATION

(FeS_2), commonly known in fuel as iron pyrites, is reduced to ferrous sulphide (FeS) as the result of the chemical reduction illustrated by the following formula:

$$FeS_2 = FeS + S.$$

As ferrous sulphide (FeS) melts at a comparatively low temperature (2138 deg. fahr.), it may surround itself with fuel and ash and form a pasty mass which may act as a binder to collect other ferrous sulphide (FeS), fuel and ash, all of which may tend to collect on, and adhere to, the hottest parts of the firebox sheets, such as staybolt heads, flue beads, and deg. fahr.; whereas by the production of ferric oxide (Fe_2O_3), in combination with the silica present, a highly infusible clinker is formed.

As a general rule an increase in the percentage of silica, alumina and magnesium in the fuel matter will tend to decrease, while an increase in the percentage of iron, lime, potassium and sodium in the fuel matter will tend to increase the fusibility of ash, but in every case a relatively high percentage of ferrous oxide (FeO) resulting from an insufficient supply of air for combustion will be accompanied by honey-

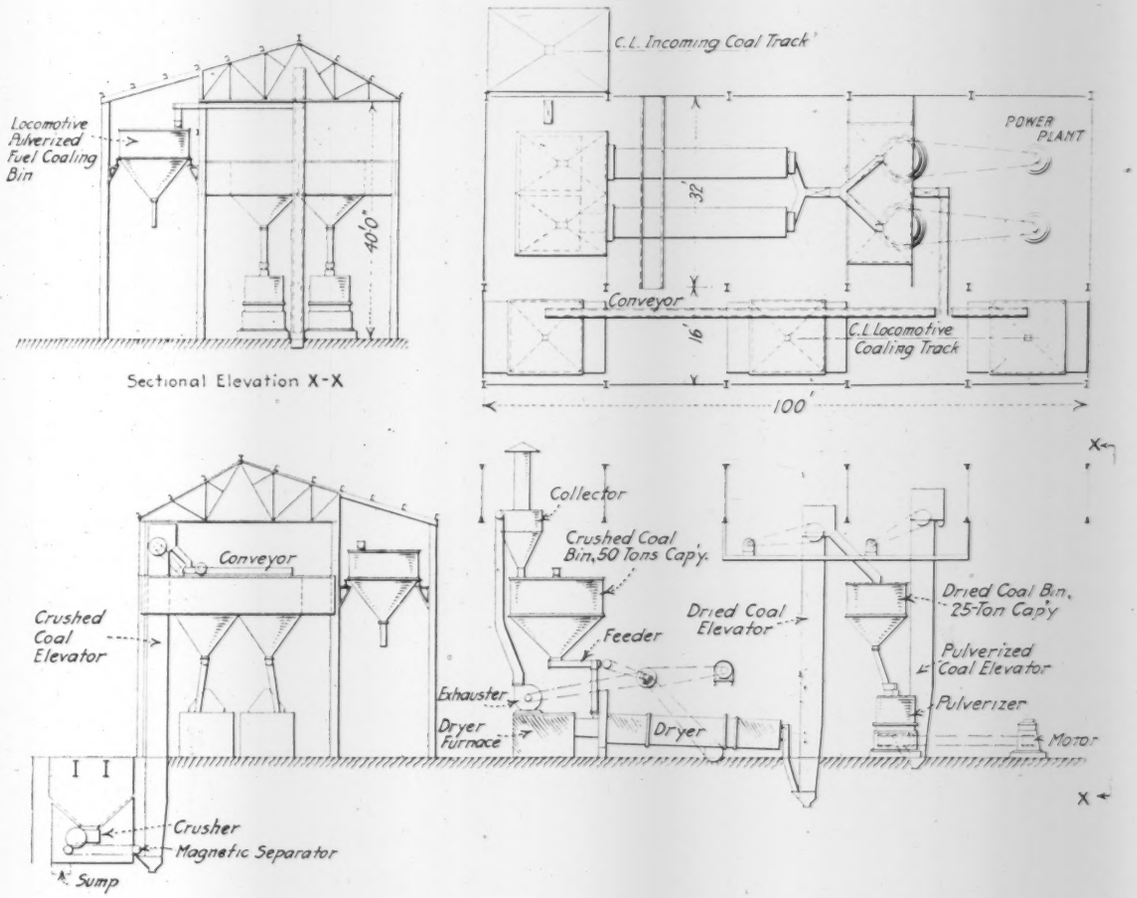


FIG. 7 16-TON PER HOUR CAPACITY DOUBLE UNIT MILLING PLANT AND TRIPLE BIN LOCOMOTIVE COALING STATION FOR THE CENTRAL RAILWAY OF BRAZIL

like parts which are higher in temperature than the melting point of ferrous sulphide (FeS) and the surrounding metal surfaces, while the temperature of the latter may be lower than the melting point of the ferrous sulphide (FeS).

The following formula shows the result of *incomplete combustion* owing to *insufficient air.*

$$2\,FeS + 2\,O = 2\,FeO + 2S$$

By providing *sufficient air* through an excess supply, the following formula shows the result of *complete combustion:*

$$2\,FeS + 9\,O = Fe_2O_3 + 2\,SO_2$$

For this latter process an oxidizing atmosphere must at all times obtain in the firebox to prevent the reduction of ferric sulphide (FeS_2) to ferrous sulphide (FeS), as expressed in the first formula.

The ferrous sulphide (FeS), as has been shown, is the direct cause of honeycomb, for the reason that it produces ferrous oxide (FeO), which unites with the silica to form a honeycomb that is very fusible at temperatures over 2400 comb formation that will tend to adhere to various parts of the firebox.

LOCOMOTIVE PERFORMANCE

For the fiscal year ended June 30, 1914, the Interstate Commerce Commission reports a total of 64,760 locomotives of all classes in the United States having made a total of 1,755,972,325 miles. This gives an average for each locomotive owned of about 27,115 miles per annum, 74 miles per day, or but little over 3 miles per hour.

From the foregoing figures it is easy to imagine that over one-half of the time of locomotives is now spent at terminals in the hands of the transportation and mechanical departments, and that most of this delay is due to the necessity for cleaning fires, ash pans, flues and smoke boxes; inspecting and repairing draft, grate and ash-pan appliances; and for

firing up and supplying firing tools and equipment. Frequently the delays to locomotives waiting to reach ashpit tracks and to rekindle fires exceeds the time required to do this work, and during the interim much fuel is needlessly consumed and the boiler subjected to excessive contraction and expansion.

With pulverized fuel a locomotive having the boiler filled with cold water may be brought under maximum steam pressure within an hour, and the fuel feed then stopped until it is called for service. When standing or drifting at terminals or on the road, the fuel feed can also be discontinued, as the steam pressure can always be quickly raised. After the trip or day's work the locomotive can be immediately stored or housed, the usual ashpit delays being entirely eliminated.

The possibilities for increasing the productive time of existing locomotives and for relieving terminal congestions that are now brought about by the necessity for cleaning and rebuilding fires on grates makes the use of pulverized fuel one of the most attractive and quickest methods for increasing the earning capacity of present single- and double-tracked steam railways.

RESULTS OBTAINED FROM USE OF PULVERIZED FUEL

From the actual operation of steam locomotives in regular train service the use of pulverized fuel has demonstrated in particular the practicability of eliminating smoke, cinders, sparks and fire hazards; increasing draw-bar horsepower per hour per unit of weight; improving the thermal effectiveness of the steam locomotive as a whole; reducing non-productive time at terminals; utilizing otherwise unsuitable or waste fuels; eliminating arduous labor; providing greater continuity of service and producing more effective and economical operation and maintenance.

The performances given in Table 1 may be of interest. They relate to a ten-wheel type of freight locomotive, rated at 31,000 lb. of cylinder tractive power, with 69-in. diameter driver wheels, when used in fast through-freight service on runs of from 91 to 138 miles in length for the purpose of testing various fuels under identical adjustment conditions.

TABLE 1 PERFORMANCES OF TEN-WHEEL TYPE OF FREIGHT LOCOMOTIVE

Item	Pulverized		
	No. 1 Bituminous	No. 2 Bituminous	No. 3 Bituminous
Fuel:			
Fineness, per cent through 200 mesh	0.85	0.85	0.85
Moisture, per cent	0.40	0.81	0.59
Volatile, per cent	24.72	36.27	24.36
Fixed carbon, per cent	68.43	58.29	65.05
Ash, per cent	6.85	5.44	10.59
Sulphur, per cent	1.96	0.68	0.84
B.t.u. per lb	14,739	14,334	13,912
Miles run, total	1,324	426	398
Cars per train, average	61	65	60
Adjusted tonnage per train, average	1,719	1,808	1,759
Speed when train was in motion, miles per hour, average	26	25	24
Boiler pressure when using steam (200 lb.), average	198.3	193.5	194.9
Front-end draft when using steam, ins. of water, average	7.15	7.79	6.69
Firebox draft when using steam, ins. of water, average	3.50	3.22	3.18
Temperature of steam, deg. fahr.	562	573	555
Coal fired per hour of running time, lb. (average)	3,275	3,063	3,457
Adjusted ton-miles per lb. of coal (average)	12.84	13.97	11.59

The locomotive was worked at its maximum capacity on all trips, about 10 per cent more tonnage being hauled than usual for like locomotives burning coal on grates, and at practically fast-freight schedule speed. The exhaust-nozzle opening was about 25 per cent larger than the maximum for hand firing.

The general results were excellent, particularly as regards tonnage, speed, combustion, and steam pressure, the latter being maintained at full speed with injector supplying the maximum amount of water to the boiler.

With the highest-sulphur coal (No. 1) and the highest-ash coal (No. 3) there was less than 1 cu. ft. of slag in the slag box at the end of each run, and practically no collection of ash or soot on the flue or firebox sheets. In fact, with the No. 3 fuel there was less than two handfuls of slag, ash and soot collected on each trip.

The steam railways in the anthracite coal-mining district generally use for their locomotive fuel mixtures which will run from 25 to 50 per cent bituminous and the balance of anthracite pea and buck sizes which will pass through a 7/8-in. and over a 5/16-in. round opening. As anthracite coal is very low in volatile, ignites slowly, and is a poor conductor of heat, the bituminous mixture is used to overcome the trouble this causes when the smaller sizes must be burned on grates, and even then it necessitates the use of unusually small exhaust nozzles to create sufficient draft.

In the experiments with pulverized anthracite fuel for locomotives the idea has been to utilize the grade of coal of lowest commercial value, such as birdseye, which is of a size that will pass through a 5/16-in. and over a 1/16-in. round opening, as well as the refuse called culm or slush, which passes through the 1/16-in. round opening and is usually wasted in the washery water or used for back-filling the mines.

To reclaim this slush a couple of wooden bins were installed, through which the washery water could be finally passed for the collection of the solid matter.

The analyses of the various fuels used may be approximated as given in Table 2.

TABLE 2 ANALYSES OF FUELS USED IN EXPERIMENTS

Item	Pulverized		
	Bituminous	Anthracite	
	Run-of-Mine	Birdseye	Slush
Moisture, per cent	0.50	0.50	1.00
Volatile, per cent	29.50	7.50	6.00
Fixed carbon, per cent	60.00	77.00	71.00
Ash, per cent	10.00	15.00	22.00
Sulphur, per cent	1.50	1.00	2.5
B.t.u. per lb	13,750	12,750	11,250
Fineness, per cent through 200 mesh	86.00	86.00	86.00

At the commencement of the development work the locomotive was equipped with an arrangement of refractory baffles and fuel and air inlets for burning 100 per cent bituminous coal, and after this has been properly accomplished successive adjustments were made to burn mixtures:

First: 75 per cent Run-of-Mine Bituminous and 25 per cent Anthracite Birdseye
Second: 67 per cent Run-of-Mine Bituminous and 33 per cent Anthracite Birdseye
Third: 60 per cent Run-of-Mine Bituminous and 40 per cent Anthracite Birdseye
Fourth: 60 per cent Run-of-Mine Bituminous and 40 per cent Anthracite Slush
Fifth: 50 per cent Run-of-Mine Bituminous and 50 per cent Anthracite Slush
Sixth: 40 per cent Run-of-Mine Bituminous and 60 per cent Anthracite Slush

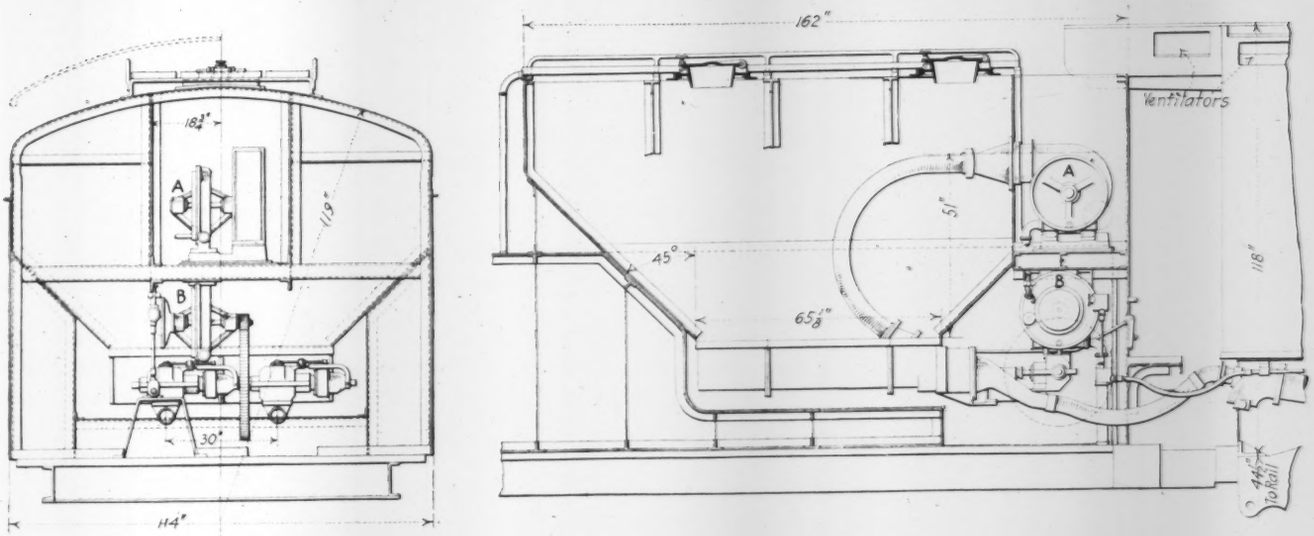


FIG. 8 DOUBLE FEEDER EQUIPMENT AS APPLIED TO TENDER FOR 10-WHEEL TYPE OF PASSENGER LOCOMOTIVE FOR THE CENTRAL RAILWAY OF BRAZIL

Further work along this same line will determine just how great a percentage of anthracite slush can be used to the best advantage, but the evaporative results so far obtained, *i.e.*, about 7 lb. of water from feed-water temperature per lb. of coal, indicates that considerably more than a 60 per cent anthracite slush mixture may be utilized. This accomplishment not only means a decrease of 25 per cent in the cost per ton for locomotive fuel, but also the release of a large tonnage of commercial anthracite, which is becoming more scarce and in greater demand each year.

The principal trouble to be overcome has been on the intermittent runs, as it is more difficult to maintain proper combustion with a slow fire and to re-ignite the fuel after the feed has been stopped for a time, with the low than with the higher volatile coals.

The same increase can be made in the size of the exhaust

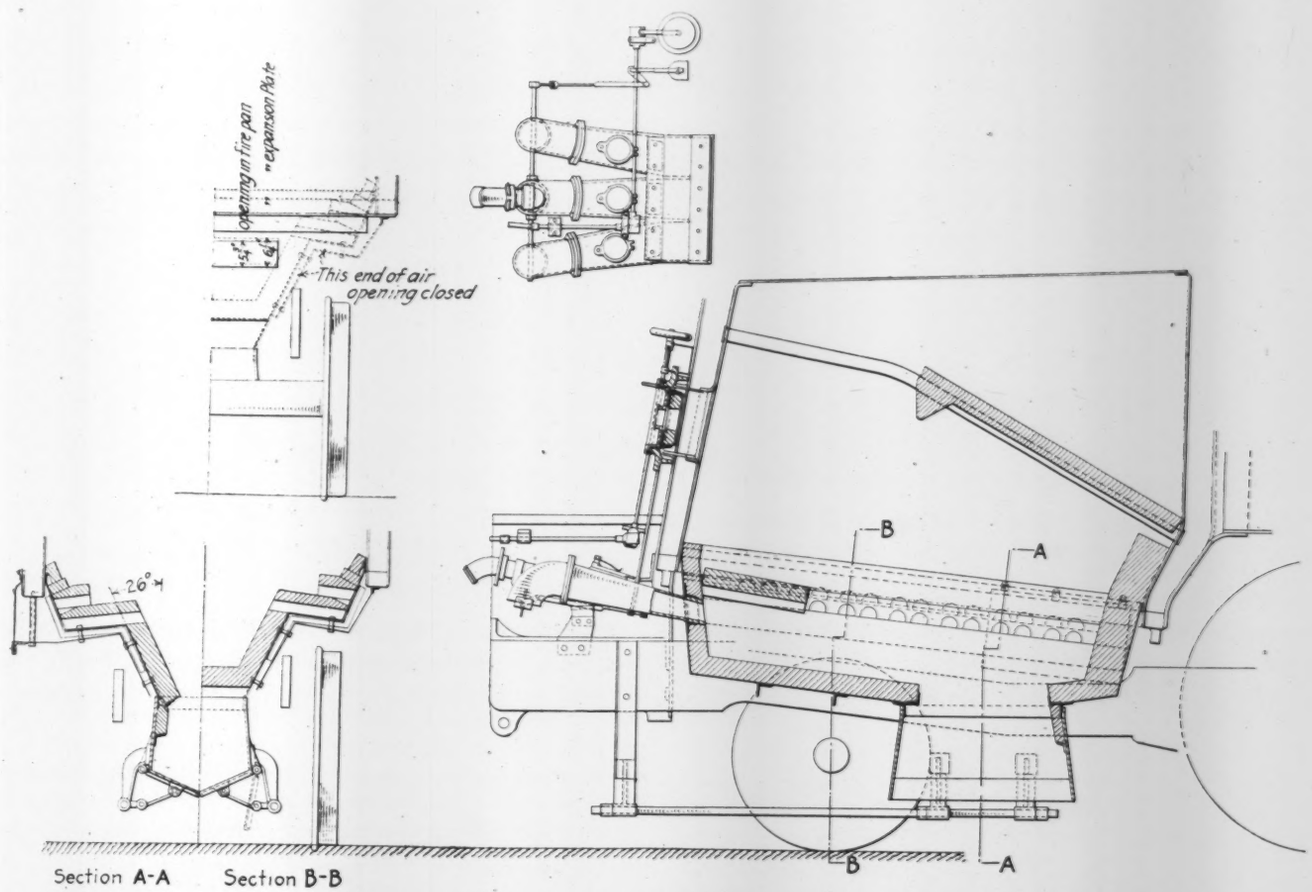


FIG. 9 TRIPLE BURNER AND FIRE-PAN EQUIPMENT AS APPLIED TO PACIFIC TYPE OF LOCOMOTIVE FOR THE NEW YORK CENTRAL RAILROAD

nozzle openings (about 25 per cent) for anthracite as for bituminous coal when burning in pulverized form, as compared with hand firing of coal on grates.

The development of sufficient drawbar pull in a consolidation type of freight locomotive with 63-in. diameter driver wheels, rated at 61,400 lb. of cylinder tractive power, to haul a freight train of 23 loaded cars (representing about 1562 actual tons) over a ruling grade of 1½ miles of 1.65 per cent grade with a 6-deg. curvature, further indicates the advantages of sustained boiler horsepower in combination with reduced cylinder back pressure, which is only made possible by this method of stoking and burning coal.

NOTES UPON PERFORMANCE

From tests made with pulverized lignite having an analysis of about 1.8 per cent moisture, 47 per cent volatile, 41 per cent fixed carbon, 9.5 per cent ash, and 0.75 per cent sulphur, and a heating value of 10,900 B.t.u. per lb., in regular passenger locomotive service, the same satisfactory results were obtained as with bituminous coals, the combustion and operating being entirely smokeless, sparkless and cinderless, and the steam pressure being fully maintained.

With pulverized fuel the control of the fuel feed and thereby of the over- or under-production of steam is nearly perfect. A locomotive can be fired up and the fuel consumption then stopped until a few minutes before starting time. At the end of the run, or when drifting, the fire can be extinguished at will and quickly re-ignited without any special equipment or materials. A locomotive with boiler full of water and 185 pounds of steam pressure, after standing 11 hours, without fire, still had 80 pounds of steam pressure.

Comparative tests made between similar locomotives in the same service resulted in the use of 2,775 lb. of lump coal, hand-fired, to get up steam and for terminal handling and dead time, as compared with 1569 lb. of pulverized screenings to produce the same result, or an increase of over 75 per cent. The greatest saving is in the firing up alone, this requiring 1700 lb. of lump coal as compared with 750 lb. of pulverized screenings, or an increase of over 225 per cent.

In the engine-house terminal handling there is the least possible delay and expense. No more time or facilities are required than for fuel-oil-burning locomotives. A locomotive fired up at 6 a. m. can leave with its train at 7 a. m., and upon arrival at the destination engine house can be immediately fueled, watered and housed, the slag pan being dumped over the engine stall pit.

Delays incident to building and preparing fires and cleaning ashpans out-bound, and for waiting to get on ashpits and to inspect and clean fires, grates, smokeboxes and ashpans in-bound are entirely eliminated, as is also the necessity for subjecting fireboxes and flues to the chilling effect of cold air due to standing around and hostlering.

Through the possibility of enlarging exhaust-nozzle openings from 25 to 50 per cent as compared with the areas required for burning coal on grates or fuel oil, the full benefit of expenditures for improved cylinders, valves and valve gears, particularly in connection with cylinders of large volume, can now be obtained. Heretofore the necessity for maintaining relatively small exhaust-nozzle openings to produce the required firebox draft has enabled but little benefit to be gained from improved steam distribution, as cylinder back pressures of from 15 to 30 lb. when operating at maximum capacity of engine and boiler are not at all uncommon in some of the most recently built stoker-fired single-expansion locomotives. As every pound of cylinder back pressure saved is equal to at least 2 lb. added to the boiler pressure when a locomotive is working at its maximum capacity, and further provides freer movement and less wear, tear and fuel consumption, the benefits to be derived are obvious.

As the limiting factor of a steam locomotive is, or should be, the ability of the boiler to produce steam, the rate and effectiveness of combustion become the controlling factors. When coal is burned on grates a rate of about 50 lb. of run-of-mine, and of about 60 lb. of lump bituminous coal, per sq. ft. or fire surface per hour is the maximum allowable for the greatest boiler efficiency. However, as this limits the rate of consumption to a total of from 3,000 to 6,000 lb. per hour for the average modern locomotive of great power, and as the actual coal supplied to the firebox by mechanical stoking frequently reaches a rate of 150 lb. per sq. ft. of grate area, or a total of from 9,000 to 15,000 lb. per hour, the boiler efficiencies frequently run as low as from 55 to 45 per cent and even less. Therefore the necessity for eliminating grates if much over 12 lb. of water per sq. ft. of evaporating surface per hour is to be obtained with reasonable efficiency.

From results established during the past six months, the quantity of live steam required for the operation of pulverized-fuel-burning equipment when the locomotive is being worked at its maximum boiler-horsepower capacity, is about 1½ per cent of the saturated steam generated, which is considerably less than what is required for the steam-jet operation of mechanical stokers when firing coal on grates, and very much less as compared with what is used in the generally existing steam-jet practice of burning fuel oil; this latter amount, according to reports made by the U. S. Naval Board, is approximately about 6 per cent of the total steam generated, exclusive of the reduction of efficiency in combustion due to the evaporation of steam into hydrogen and oxygen and back into H_2O in the firebox.

Comparing the use of pulverized fuel and fuel oil for steam-locomotive purposes, it may be stated that with pulverized coal at 13,750 B.t.u., costing $2.35 per ton, and fuel oil at 19,500 B.t.u., costing $2.75 per ton, an amount of at least $2.50 must be expended for the fuel oil necessary to perform the same useful work as will obtain from $1.00 expended for pulverized fuel.

As anthracite slush is not burned on grates, no comparison is available for the pulverized performance. However, comparing the performance of anthracite birdseye hand-fired on grates equipped with forced blast below and induced draft above the fire, with the same fuel pulverized and burned in suspension, there is an average increase of over 40 per cent in the evaporation in favor of the latter.

In general, it may be stated that the use of pulverized anthracite slush will double the steam-generating capacity of boilers now burning birdseye anthracite hand-fired on grates, and at the same time eliminate fire cleaning, greatly decrease the amount of ash to be handled, and reduce the boiler-plant labor cost about 40 per cent. Furthermore, with the pulverized fuel the boiler pressure can be more readily maintained or increased or reduced to meet the requirements, and when one or more of the boilers are not needed temporarily, the fuel feed can be stopped and started at will, thereby eliminating the necessity for maintaining banked fires and burning fuel when not required in order to have the boilers ready for instant use.

STEAM BOILER PAPERS

TWO of the steam boiler papers to be presented and discussed at the Friday morning session in charge of the Boiler Code Committee are given below. The first of these describes a new type of contra-flow boiler. The second is a practical paper on safety valves.

THE TALBOT BOILER

By PAUL A. TALBOT, NEW YORK, N. Y.
Non-Member

THIS is essentially a boiler of the contra-flow type, water entering near the stack and leaving in the form of steam near the furnace. The circulation is through water tubes and is forced at a high velocity by means of a pump, doing away with a water drum. By preventing gravity circulation, the steam is drawn directly from the lower tubes, eliminating the steam drum. The boiler is internally fired,

FIG. 1 FRONT OF BOILER, CASING REMOVED

a Automatic regulator valve, *b* Oil valve, *c* Hand valve, *d* Main check valve, *e* Main steam pipe, *f* Separator, *g* Separator drain, *h* Combustion space, *m* Atomizer pipe, *n* Burner valves

and hence self-contained. Feed water and fuel burners are automatically controlled to adjust the boiler to widely varying demands for steam. The boiler should not be confused with "flash" boilers in which the heat-charged tubes furnish steam in direct proportion to the feed supply without regard to the control of the fire. By means of the high velocity, forced circulation and contra-flow principles, the evaporative capacity of the boiler is largely increased.

Any or all of the tubes may be readily removed and replaced without disturbing any manifolds, pipes or connections. Official tests recently carried out in the Navy Yard, New York, included a tube renewal test of a 100-horsepower boiler. A tube was removed from the boiler under 250 lb. steam pressure and replaced by another tube in 61 seconds, the total period between the time of shutting off the fire and feed water and the time of regaining full pressure and maximum capacity of operation being 3 minutes and 16 seconds.

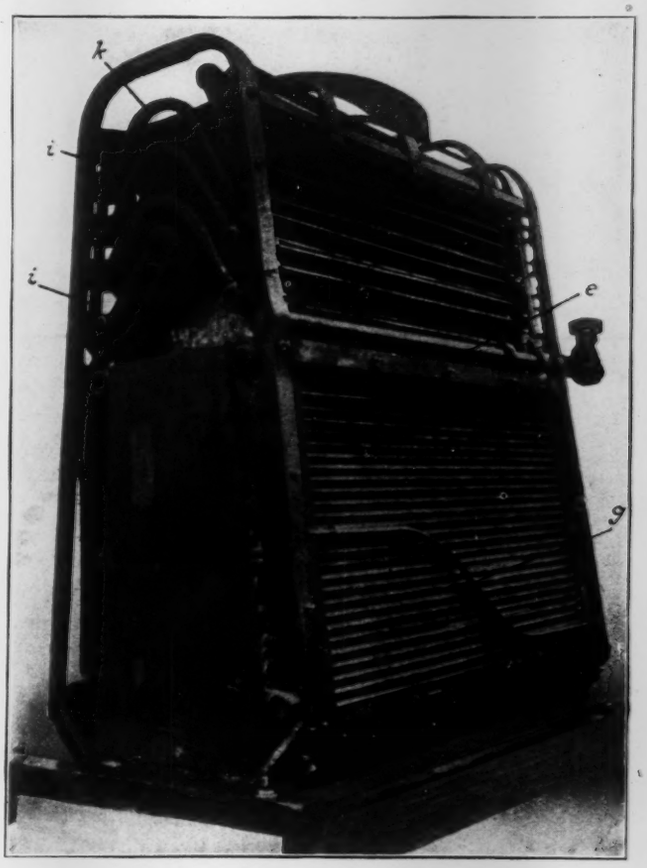


FIG. 2 REAR OF BOILER, CASING REMOVED

f Separator, *e* Main steam pipe, *g* Separator drain, *i* Feed pipe, *k* Trap

CONSTRUCTION

An idea of the general construction of the boiler may be obtained from Figs. 1 and 2. Fig. 1 shows the front and Fig. 2 the rear of the boiler with the casing removed. Fig. 3 shows the complete boiler with its casing. The illustrations are of a boiler having an evaporation of 15,000 lb. of water per hour with ¼ in. of water draft, 20,000 lb. per hour with 1 in. draft, and double the normal capacity at slightly above 2 in. draft.

The frame consists of front and rear sections, roughly re-

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

sembling horseshoes in shape, fastened together at top and sides by lateral ties and at the bottom by the ash pan and additional ties. The stack ring and upper panel work are supported by frame work bent to conform to the curve of the front and rear frames. For fastening the boiler in position, feet are provided which are bolted to the main frame through the ash pan. The door frame, of angle cross-section, is fastened at the top and bottom to the main frame, and serves as a support for regulating valves shown in Figs. 1 and 3 and described more fully later.

The tubes throughout the boiler are all alike. As will be seen in Fig. 4, the crucible steel header consists of two sets of overlapping compartments, into one of which is screwed the open-end field tubes, and into the other the generating

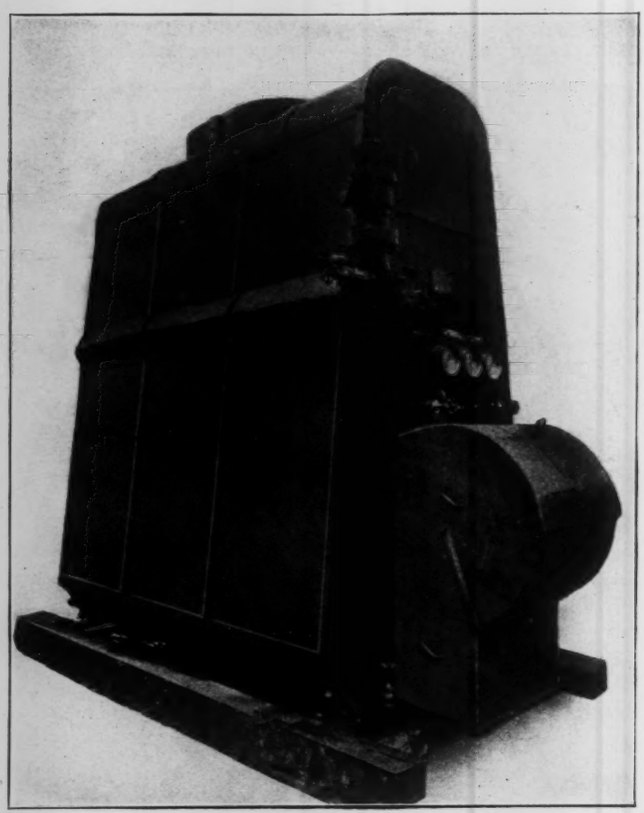


FIG. 3 FRONT OF BOILER WITH CASING

a Automatic regulator valve, *c* Hand valve, *n* Burner valves

tubes, there being an annular space between the two tubes. The end of each generating tube is welded together so as to close it. These closed ends are free to expand and are supported in front by perforated sheets of metal. The method of fastening the tubes into the headers is shown in Fig. 5. Both tubes are threaded with double the standard taper, which makes it easy to remove them. The fit is sufficiently tight to hold a pressure of 1000 lb. per sq. in., using standard weight pipe.

Five sets of tubes with horizontal headers are placed above the combustion space, and on each side of the combustion space is placed another set of tubes with headers arranged vertically. The rear of the furnace is closed by a wall containing water-circulating passages connecting the tubes on the sides, as shown in Fig. 2.

Between each set of headers is a *trap connection*, shown in Fig. 2. These traps perform the important function of preventing water from draining by gravity from one header to the next below until sufficient water is forced into the upper header. The formation of steam prevents the water from syphoning when circulation is at rest, and the correct amount of water is thus maintained in each header, in readiness for full capacity demands.

Accessibility. There are three doors in the front of the boiler, which, when opened, give access to the free ends of all the tubes. Any tube can be removed by applying a wrench to its end and unscrewing it from its header.

OPERATION

The circulation of water is maintained by a pump, delivering the feed water to the main check valve at the bottom of the doorframe, from whence the water rises in a core and passes around the door frame to the regulator valve. The water then passes to the rear of the boiler to the uppermost set of tubes. In order to understand the circulation through the tubes, reference must be made to Fig. 4, which shows a typical header and tubes forming a single section, the path of water through it being indicated by arrows.

Having passed through the first set of field tubes and returned to the inner compartment of the header by way of the annular space in the generating tube, the water returns to the front of the boiler through a similar annular space in the next set of tubes and back to the outer compartment of the header by way of the inner field tubes. This process is repeated until the water has traversed to the opposite end of the header, where it passes out, through a trap connection, to the header immediately below. Passing from header to header the water has a general downward direction to the set of tubes, which is on the left side of the furnace, as seen in Fig. 2. The circulation through all sections of tubes is the same.

Referring to Fig. 2, the steam or water from the set of tubes on the left of the furnace enters a rear wall, which is partitioned to carry it at high velocity from one side to the other until it is finally discharged, at the bottom of the right-hand corner, into the set of tubes on the right side of the combustion chamber.

During this passage the water has gradually changed to steam, and it now leaves the last set of tubes through the herringbone steam separator at the back of the boiler and enters the steam pipe, crossing to the front of the boiler, where safety valve and steam nozzle are located. The separator drain passes to the front of the boiler, where the valve controlling it is located.

The length of water passage from the point of entering the boiler to the point of leaving it varies with the size of the boiler. The passage in a 1000-horsepower boiler is 795 ft. long, 668 ft. of which is through tubes. The areas through which the water flows also vary with the boiler and are restricted to increase the velocity of flow.

The friction of water and steam by reason of the restricted areas is about 100 lb. at normal load. This friction increases as the load increases.

The velocity through the boilers in which larger tubes are used is much greater than when smaller tubes are used. Thus the velocity of the steam in the last stages of the boiler varies from 6000 to 12,000 ft. per min., depending upon the size of boiler tubes used. This velocity increases, of course, as steam is formed, so that the velocity in a large boiler is about 500 ft. per min. in the first and 12,000 ft. per min. in the last passages when in the form of steam.

A high rate of evaporation is obtained because of the high

velocity of water through the tubes. The tubes which line the furnace evaporate as much as 30 lb. of water per sq. ft. of heating surface, while the average, including economizer and superheating surface, is 8 lb. per square foot at rated capacity.

The formation of scale is prevented by the high velocity and consequent scouring action of the water, which keeps the solids in constant motion. The actual velocity great enough to prevent scale formation is not known, but it has been determined that with a velocity as low as 60 ft. per min. and very poor water, mud forms in the economizer section of the boiler. The water tested was alkali, of 27 degrees hardness, such as is found in desert regions. With a normal velocity of 500 ft. per min., such as is used, a minimum velocity of 150 ft. per min. can be maintained at partial loads. It has been found that at very low velocities the deposits have been confined to the water portion of the boiler where the temperatures are between 100 and 150 deg. fahr. As the entire heating surface is active and subjected to these high velocities, feed-water purifiers are not necessary for this boiler.

The soot blower. The soot which forms on the economizer

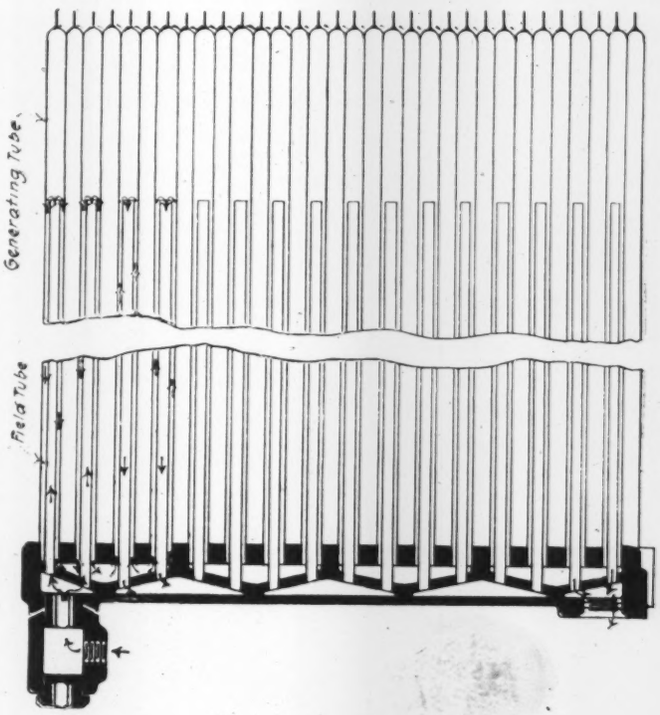


FIG. 4 DIAGRAMMATIC SECTION THROUGH HEADER AND TUBES
Arrows show Course of Water Circulation

surface of the upper sets of tubes is blown from them by longitudinally directed steam jets situated near the ends of the tubes. Steam is supplied from the main steam pipe, and valves for the control of the jets are on the front of the boiler. The jets have proved a satisfactory method of keeping the surface relatively free from soot. The tubes at the sides of the furnace are practically free from soot, and it is probable that if any soot collects on them it eventually ignites. Exterior as well as interior surfaces of the boiler, therefore, are always clean, eliminating the periodic overhauling and cleaning.

THERMOSTATIC CONTROL

The expansion of one of the tubes of the last set at the side of the furnace under the varying temperatures of steam contained within it, is multiplied by means of levers and utilized as an automatic thermostatic control of both water and fuel supply. Arrangement is made so that the operator may easily and quickly adjust the thermostat to meet the demands. The slightest rise in temperature of the outgoing steam causes sufficient expansion of the tube to open the regulating valve on the front of the boiler and admit a greater quantity of water, thus lowering the temperature of the steam. In case the operation of the thermostat has not prevented the rise in temperature, as might happen under partial load or insufficient water supply, it will cut off the supply of fuel to the furnace. At low temperatures the supply of fuel is increased by this same thermostat.

Details of the thermostat. The expansion and contraction of the tube and the movement of the regulating valve is shown

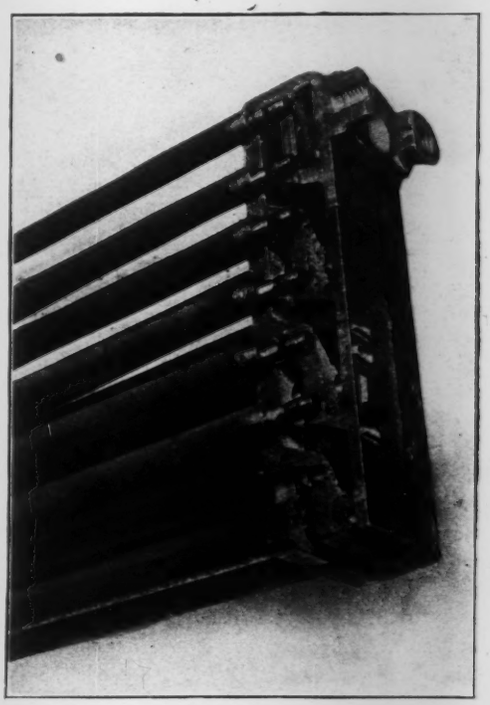


FIG. 5 INSERTING TUBES IN HEADER

by a gage, which is arbitrarily graduated for convenience in indicating the relative temperatures, and may be calibrated by means of a mercurial thermometer so that the operator may judge from it the temperature of the steam. Thus it might be determined that with a gage reading 2⅜ the temperature of the steam is 650 deg. fahr. Having determined the point for the temperature he desires, the operator can regulate the thermostat to maintain the gage at this point. This reading is checked occasionally, as changes in the frame, header or tube, due to wear or seasoning, may make corresponding changes in the calibration of the gage, so that some other point registers the 650 deg. which the operator is trying to maintain. This temperature gage serves the purpose of the water column of the ordinary boiler. The temperature of the steam delivered tells the operator whether or not the supply of water is adequate, as it is obvious that with too little water at full capacity the temperature of the steam will rise and indicate this condition on the gage.

Hand valve. The action of the automatic valve is fairly close, but, due to the fact that the regulator tube is not instantly affected, there occur periodic changes in temperature and pressure. A hand valve is provided for eliminating this action under normal loads. This valve is arranged to shut

off completely the supply of water when closed, and is marked with arbitrary graduations from which the operator may determine at what point it should be set for the best results. When the hand valve is closed too much, it is obvious that the supply of water may be so limited that the temperature will rise to a point where the fuel valve will close. When the valve is opened too much, there will be a periodic variation in the temperature of the steam due to the lag of the controlling thermostat. The point should be determined, therefore, which will allow the regulating valve to be opened all of the time, preventing the periodic variation in temperature due to too frequent shutting down of the fuel valve. The accuracy of adjusting this valve determines the accuracy of temperature control under full-load conditions. Experience has shown that on a 25 per cent load the valve does not require adjustment, but the temperature of the steam will be much less due to an over supply of water to a reduced fire. By readjustment of the valve the full-load temperature can be maintained at fractional loads. At less than 25 per cent capacity, a readjustment is necessary to prevent the periodic variation in temperature. The ordinary fireman can easily maintain a constant pressure and temperature by means of this hand valve.

OIL BURNER

A steam atomizer oil burner is arranged at the front of the boiler near the top of the inflow of air for combustion. The air is heated and carried in a general downward direction by the air duct, a sheet-metal addition to the front of the boiler having an S-shaped air channel. (See Fig. 3.) The quantity of air can be adjusted by dampers in this duct. Highly superheated steam is used to heat and vaporize the oil and to promote the velocity of the hydrocarbon mixture which issues from the burner tips. Very heavy Mexican oil, 11 Baumé can be used in this burner. A number of burner tips shoot the flame downward into a firebrick target at the lower rear end of the furnace. This refractory target or oven is designed to distribute the heat uniformly over the entire heating surface. Temperatures of 3800 deg. fahr. are obtained within this oven, but, as few bricks are used, the upkeep cost is small.

The intensity of the fire is easily controlled by increasing or decreasing the volume of steam used in atomizing the oil. The flame has the effect of a large blow torch, and as the velocity is carried to an extreme, considerable noise is experienced. This is not a detracting feature in marine practice, as it is confined to the fire room.

FURNACE JACKET

As the heating surface surrounds the furnace on all sides, the insulation of the jacket is easily accomplished. The insulating material is applied in plastic form and fills the entire space between the sheet-metal casing and the tubes themselves. While this system is preferred, the various methods of applying insulating material in boilers having sheet-metal jackets may be used, or brick settings may be installed where space, weight and vibration are not points for consideration.

EFFECT OF FORCING

The thermal efficiency of this type of boiler is affected in much the same manner as in boilers of other types, although the drop in the efficiency curve is not so pronounced at higher draft pressures and higher evaporative rates, due to the fact that when forced the economizer surface in the upper part of the boiler is correspondingly increased and the stack temperatures are relatively lower. More water is introduced, and the superheating surface is reduced nearly in proportion as the load is increased.

AN ANALYSIS OF MARINE SAFETY VALVES

WITH SUGGESTIONS FOR REPAIRS AND IMPROVEMENTS

BY E. F. MAAS, PUGET SOUND, WASH.

Member of the Society

THE PURPOSE of this article is not to give a complete description of all marine safety valves to be found on the market today, but to analyze certain characteristics of some of the more common types, to indicate advantages and difficulties to be expected with them, and to point out helpful methods in repairing and improving old valves. The paper presents the results of observations made on valves under working conditions and during tests of repaired valves in the mechanical laboratory.

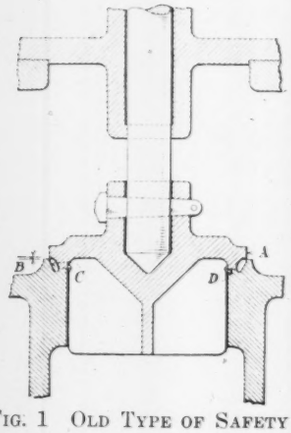


FIG. 1 OLD TYPE OF SAFETY VALVE

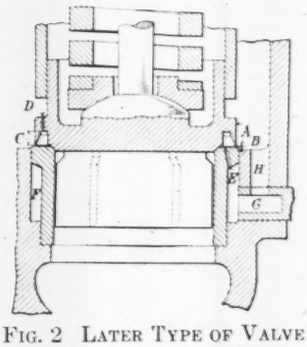


FIG. 2 LATER TYPE OF VALVE WITH ADJUSTABLE BLOW-DOWN

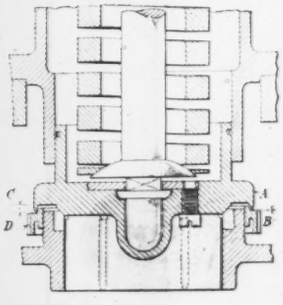


FIG. 3 MODERN SAFETY VALVE WITH ADJUSTABLE BLOW-DOWN

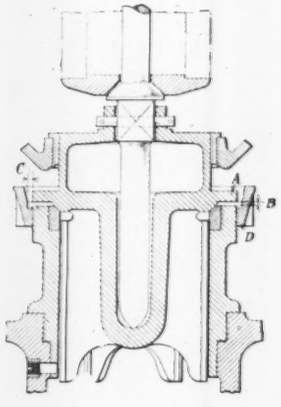


FIG. 4 RECENT TYPE OF MARINE SAFETY VALVE

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision

Fig. 1 represents a valve of an obsolete design, probably not being made by any manufacturer today. This type is still to be found in many of the older ships and should be taken in consideration. Fig. 2 shows a later type of valve having attachment for adjusting the blow-down, an indispensable feature in a modern marine safety valve. Fig. 3 is much the same as Fig. 2, the main difference between them being in the design of the blow-down adjustment. Fig. 4 represents one of the latest and most successful designs at the present time. In Fig. 5 is shown a valve which has not yet fully emerged from the experimental stage, but one for which a preliminary analysis and test reports show great possibilities. Figs. 6 and 7 show modifications made to valves of the type represented by Fig. 3, these modifications having been applied during the repair of these valves in order to fit them for further service after their original working adjustment had been destroyed through long service or neglect in maintenance.

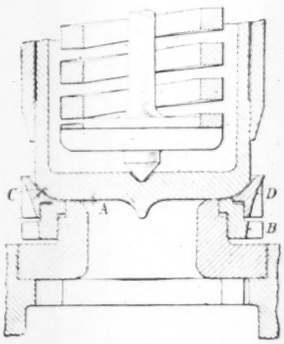


FIG. 5 EXPERIMENTAL VALVE

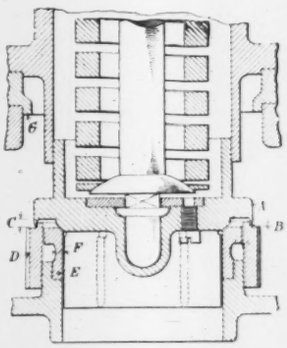


FIG. 6 MODIFIED SAFETY VALVE OF TYPE 3

The features discussed in this paper are:

a Valve seat, flat or beveled, and tightness
b Pop of valve, amount of simmering before pop, and height of lift
c Closure of valve, and chattering at closure
d Blow-down of valve, and methods for adjusting
e Discharge capacity
f Repair and adjustment of old valves and improvements accomplished at slight expense

VALVE SEAT

A glance at the seven figures will disclose the fact that valves in Figs. 1 and 5 have flat seats, the other five having beveled seats. While there are good arguments on both sides, the experience of the author has been that a flat seat is just as easy to grind in and make tight as a beveled seat, and that the flat seat is more likely to stay tight. On account of the distortion of the valve seat, which will result from a slightly uneven expansion or from spring of the material under high pressure, the tightness of a beveled seat is seriously affected, and the more so the greater the bevel. A flat seat will remain steam-tight even after a considerable distortion has taken place, provided the valve has been carefully ground to its seat in the first place. For equal lifts, a flat-seat valve will have a greater discharge capacity, under conditions discussed later; a fact which will weigh in favor of the flat seat. It has been argued that a beveled seat, especially where the bevel is about 45 deg., will more easily rid itself of particles of scale lodged between the valve and its seat. Attention should be called to the custom where there is scale under the valve, of tightening the valve by turning the valve stem. Such practice is likely to have an effect directly opposite to what is desired. It is better to lift the valve from its seat by the easing gear and thus blow the scale from the valve seat. A steeper bevel than 45 deg. is inadvisable for a steam safety valve because of the tendency of the valve to stick. While only a few years ago most safety-valve specifications called for seats beveled at an angle of 45 deg., this has now been abandoned in many specifications, notably those of the U. S. Navy Department and various State boiler rules. It is the author's opinion that a change from the beveled to the flat seat will better the conditions affecting the working and repairing of marine safety valves.

POP OF VALVE

By "pop" of a safety valve is meant the instantaneous rise to almost full lift after the first tendency of the valve to move from its seat, or simmer. A satisfactory pop is essential in a successful safety valve. The absence of the pop will mean a prolonged simmering of the valve, which will soon score both valve and seat, especially if steam is superheated. The pop of the valve in Fig. 1 is determined by the diameter of the flange *A*, the amount of the distance *B* and, to some extent, the shape of the surface *C*. It is assumed that the valve has been ground to its seat and made tight. A knowledge of the proper relation of these factors is necessary for the design of this valve. When this valve is refaced and reground it is of utmost importance that gages for the original shape of both valve and seat, and the proper distance between the two, should be furnished the machinist. A valve of this kind requires a long spring in order to give a satisfactory lift, on account of the comparatively small overhang of the flange *A* over the seating surface of the valve, limiting the available additional lifting force required after the valve has started from its seat.

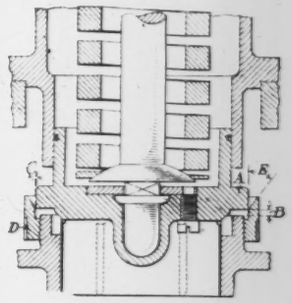


FIG. 7 ANOTHER MODIFIED VALVE OF TYPE 3

In a valve such as shown in Fig. 2, the pop will depend on the diameter of the flange *A*, the amount of the distance *B*, the depth *C* of the main pop chamber, and the size and number of the holes *D*. Of these four items, *A* and *D* are determined by the manufacturer of the valve, and if rightly proportioned need not be altered in repairing the valve. Items *B* and *C* are affected by the wear and repair of the valve. The lip *A* should wear down in the same proportion as the valve and seat, but as this is very seldom the case, there arises the necessity for adjustment when the valve is overhauled. The depth of the pop chamber does not influence the pop as

greatly as does the distance between the flange lip and the valve bushing. The former, therefore, is checked only roughly, while the distance B must be absolutely correct.

In Figs. 3 and 6, the pop is decided by the three factors, size of flange A, distance B, and depth of pop chamber C. The distance B can be adjusted after the valves are assembled, by means of the blow-down ring, D. Thus it does not seem necessary to machine accurately the lip A in repairing these valves. Such is not always the case, however, as the adjusting of the distance B for a satisfactory pop may interfere with the adjustment for the desired blow-down. This will be explained in more detail later.

In valves of Figs. 4 and 7 the pop depends upon the size of the flange A, the distance between flange and valve seat B, and the width of the ring-shaped opening at C. In Fig. 4 the deciding factor is the distance B, whereas in Fig. 7 the pop will be determined mainly by the distance C. Therefore, in overhauling valve of Fig. 4, strict attention must be paid to the distance B in order to bring it back to its original value. In valve of Fig. 7 only a rough check of distance B need be made, and as the width of the ring area C has been fixed in making the valve parts, it need never be changed.

The pop in Fig. 5 depends upon the distances A and C, which can be regulated by means of the adjusting rings B and D. The inner ring should be screwed close to the valve disk without touching it. The outer ring furnishes the greater part of the additional lifting force.

BLOW-DOWN

For adjusting the blow-down, or difference in steam pressure under the valve at popping and at closure, there are two systems represented in the valve shown. Valve of Fig. 1 has no adjustment of the blow-down. The amount of blow-down desired must be decided on in advance, and the valve designed accordingly.

The arrangement in Fig. 2 for adjusting the blow-down is probably familiar to most steam engineers. When this valve discharges, part of the steam passes through the holes E drilled in the bushing and into the chamber F. The only exit from this chamber is through the bushing G and the passage H communicating with the discharge space of the valve casing. By turning the bushing and locking it in different positions, the size of this exit passage for the steam can be restricted, thereby regulating the pressure under the valve lip A. The holes D in the valve flange will have a similar influence on the blow-down. The size and number of these holes are generally proportioned to admit of a minimum blow-down of, say, 4 lb. A smaller blow-down than this should not be used in any safety valve, as it shortens the life of the valve and produces a tendency to chatter, without any additional advantages.

In all of the valves of Figs. 3 to 7 the adjustment of the blow-down is accomplished by means of the adjusting rings, D. Screwing this ring up will increase the blow-down and screwing down decrease it. The rings of Figs. 4 and 5 are especially adapted to give a minimum obstruction to the flow of steam and so increase the discharge capacity of the valve. It has been claimed for the ring of Fig. 5 that, in conjunction with the lower ring B, it has the effect of reducing the lifting force at very low lifts and increasing it as the lift increases. This is a most desirable feature in any safety valve.

The ring in Fig. 7 has been designed as an improvement on those of Figs. 3 and 6. It has already been pointed out that in these valves the pop is determined by the distance B; and that the position of the ring D determines the amount of the blow-down. Thus there are two factors to be considered in determining the proper position of these adjusting rings, and each of these factors may require a different setting of the ring. In such a case it is necessary to take out the valve disk and machine its lip A until the proper distance between this lip and the adjusting ring is obtained, after first determining the position of the adjusting ring for the desired blow-down. Such a procedure is tedious unless gages are available for the machinist. In order to eliminate much of the machine work in overhauling and adjusting this kind of valve, the modifications shown in Fig. 7 were devised. The lip of the valve disk has been cut away and the diameter of flange slightly reduced. The shape of the blow-down ring has been changed entirely and made somewhat similar to the one in Fig. 4. The feature of the ring in Fig. 7 determining the blow-down is the angle E. An angle of 36 deg., 30 min. has been found to give a range of blow-down of from 4 to 9 lb. The laboratory tests on this improved valve have given very good results as to popping and blow-down.

DISCHARGE CAPACITY

When steam under pressure is allowed to flow through an opening, the maximum discharge will be obtained when the pressure on the low-pressure side is equal to, or less than, 58 per cent of the pressure on the high-pressure side. Under such conditions, the pressure at the throat section, or most contracted part of the channel through which the steam is flowing, will be 58 per cent of the high pressure, regardless of how much the pressure in the discharge chamber falls below this value. The weight of steam discharged can then be calculated from the well-known Napier formula: *Flow in pounds per second = absolute pressure* $\times$ *area in square inches* $\div 70$. Valves in Figs. 1, 2, 4, 5 and 7 undoubtedly have their throat section at the inner circumference of the valve seat. Therefore, the area of opening at this section will determine the discharge capacity of the valve, provided that the resistance to the flow is not made great enough to raise the pressure in the valve casing above 58 per cent of the pressure under the valve seat. Based on Napier's formula, and making allowances for reductions of the free opening over the valve seat, caused by guide wings, the following approximate formulae, given by some manufacturers, are obtained for calculating the discharge capacity:

$$W = 149\ lpd \text{ for a flat seat}$$
$$W = 105\ lpd \text{ for a 45-deg. bevel seat}$$

where W = discharge in lb. per hour
l = lift of valve in inches
p = absolute pressure under valve disk in lb. per sq. in.
d = diameter of valve seat in inches

For equal lifts, then, the flat seat will give a greater discharge than the 45-deg. seat. The discharge capacity will be influenced to some extent by the smoothness of the approach to the throat section. On this account the valve of Fig. 5 should have an excellent discharge capacity. With the valves of Figs. 3 and 6 it is frequently found that the actual discharge capacity is considerably below that obtained from the above equations. This can be accounted for by the throttling, especially at lower lifts, taking place under the valve lips.

The paper concludes with paragraphs dealing with simmering before lift, essential to successful working; prevention of chatter at closure, and methods of repairing and adjusting existing valves to make them successful and satisfactory.

TEXTILE PAPERS

THE work of the Sub-Committee on Textiles is devoted to securing papers upon the mechanical engineering and allied features of the textile industry. The Sub-Committee contributes three important papers to the Annual Meeting this year, one of which, bearing upon the heating of mill buildings, is published below.

SPONTANEOUS IGNITION STUDIED BY MEANS OF PHOTOGRAPHIC PLATES

By FREDERICK J. HOXIE, BOSTON, MASS.
Member of the Society

SPONTANEOUS ignition is a much more common cause of fires than is generally supposed. Many familiar substances can ignite spontaneously at slightly elevated temperatures or if acted upon by strong sunlight. Fires from this source are in the class most dangerous to life and property, because they start at the least expected time and place, and when no one is near to extinguish them or to give the alarm. The study of this class of fires, therefore, offers an attractive field of usefulness for the fire-protection engineer; but the pursuit of such studies is beset by difficulties arising from a lack of exact knowledge of the chemistry of oxidation and lack of convenient methods of studying the early stages of combustion.

The ignition of a handful of excelsior with a match is familiar to all: the match raises the temperature of a small amount of the wood above its ignition point, which is about 500 deg. fahr.; the combustion of this wood then raises the temperature of the surrounding particles above their ignition point, and the flame spreads rapidly through the excelsior. If the excelsior is wet, or is pressed close against a cold surface, the velocity of combustion may not be sufficient to keep the surrounding temperature up to the ignition point, in which case it will smolder, and its flame or glowing coal will "go out." The effect of the flame from the match is to render the oxygen of the air, which at lower temperatures is inert, sufficiently active to combine with the wood.

OXYGEN CAN BE MADE ACTIVE BY SUNLIGHT AND ELECTRIC CHARGE AS WELL AS BY HEAT

This quickening of oxidation may be accomplished, although much less thoroughly, by sunlight or other light of short wave lengths, by an electric charge, or by radioactive materials. Oxygen in this condition is said to be activated, ionized, or, when in this state as a result of just emerging from a chemical combination, nascent.

On the other hand, the wood instead of the oxygen, may become activated. If the wood is partially rotted or charred, or is in intimate association with oxygen-carrying materials, it may be caused to ignite after a considerable time at a surrounding temperature below 300 deg. fahr., or very much below the temperature at which it can be ignited under normal conditions.

The sight of dry cotton or of the fine shavings of soft wood known in the trade as "excelsior" in contact with the oxygen of the atmosphere in sunlight with no apparent oxidation or combustion, is too familiar to attract attention. If such material should burst into flame spontaneously at the ordinary temperature of the air, this action would be regarded as little short of a miracle. Nevertheless, this cotton and excelsior are all the time very slowly burning or being oxidized at the ordinary atmospheric temperature, the velocity of this oxidation or slow combustion depending on the temperature, moisture, light and mineral or organic substances associated with the cotton or wood.

Cotton cloth which has been exposed for several months to sunlight and atmospheric moisture to the extent of so-called "dampness," exhibits on close inspection somewhat of the same charred appearance that it has after a few seconds' contact with a hot iron. The addition of certain mineral substances, known to chemists as catalyzers, such as iron and manganese, which can act as carriers of oxygen, accelerates

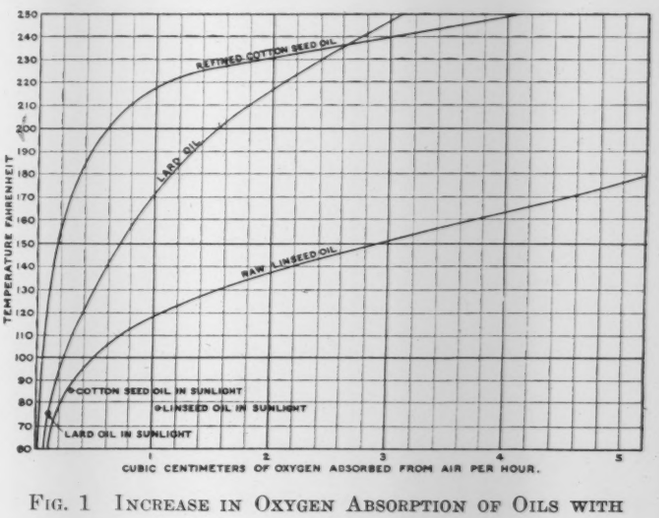

REFINED COTTON SEED OIL
LARD OIL
RAW LINSEED OIL
COTTON SEED OIL IN SUNLIGHT
LINSEED OIL IN SUNLIGHT
LARD OIL IN SUNLIGHT
TEMPERATURE FAHRENHEIT
CUBIC CENTIMETERS OF OXYGEN ABSORBED FROM AIR PER HOUR.

FIG. 1 INCREASE IN OXYGEN ABSORPTION OF OILS WITH INCREASE IN TEMPERATURE

this action. This slow combustion liberates the same amount of heat per pound burned that would be liberated by the more familiar combustion with flame, but the heat is given off over such long periods of time that the resulting rise in temperature is not appreciable.

VELOCITY OF COMBUSTION INCREASES RAPIDLY WITH TEMPERATURE

If, however, the slowly burning substance is completely inclosed by material of high heat-insulating power, the heat generated by the combustion will be made to escape more slowly and the temperature will be increased proportionally. The velocity of combustion increases with the temperature and more rapidly than the first power of the temperature, as shown by the curves in Fig. 1 giving the rate of oxygen absorption, which is the first stage in combustion. On the other hand, the escape of heat will be more rapid with higher temperature and the same heat insulation; so that in most cases in common experience the velocity of combustion, the rise in

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis on application. All papers are subject to revision.

temperature and the radiation of heat each soon comes to equilibrium.

In many cases where the substance is enclosed or shielded from atmospheric circulation, the exhaustion of the oxygen of the air in contact with the burning substance limits the oxidation. If, however, the heat insulation is sufficiently good and the necessary air supply is available, and if the temperature is sufficient to cause the combustion to proceed at a rate which increases more rapidly than the increase in the rate at which the heat is being radiated, ignition will result.

CURVE OF VELOCITY OF OXIDATION SIGNIFICANT

In this connection the form of the velocity-of-combustion curve gives the most significant characteristics of substances subject to spontaneous ignition. In studying this hazard it is important to know both the velocity of combustion of a given substance at the ordinary temperature of the air and *also the temperature at which this velocity commences to increase rapidly, as indicated by the hump on the velocity curve;* such, for example, as is found at 100 deg. fahr. for linseed oil and at 200 deg. for cottonseed oil. See Fig. 1.

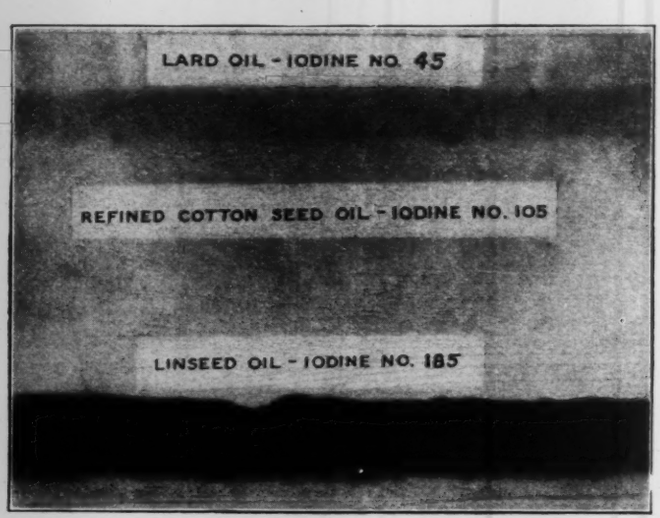


FIG. 2 IMAGES MADE ON PHOTOGRAPHIC PLATES BY OILS OF FIG. 1

To obtain practically this curve of the velocity of combustion for different substances at the ordinary temperature of the air is a difficult matter. To determine it by the rate of absorption of oxygen as shown in Fig. 1 is a troublesome and uncertain process, owing to the fact that there are doubtless many intermediate reactions between the combination of oxygen and wood or cotton or other hydrocarbons and the end products, which are carbonic acid and water. Therefore, any means of determining this curve or of *comparing the velocity of oxidation of substances of which the characteristics are unknown with that of substances of which the characteristics are known,* will be a valuable help in studying the mysterious mechanism of spontaneous ignition.

SUBSTANCES UNDERGOING AUTOMATIC OXIDATION GIVE OFF HYDROGEN PEROXIDE

Schoenbein showed that many substances undergoing automatic oxidation give off hydrogen peroxide.[1] Moritz Traube later pointed out that many of these substances *would not oxidize automatically except in the presence of water,*[1] and propounded the theory, which bears his name, that the hydrogen peroxide is formed by the combination of the oxidizable substance with the oxygen of water, the hydrogen of the water combining with free oxygen to form hydrogen peroxide. This cycle would make moisture a necessary part of an automatic oxidation, an equal number of molecules of water and oxygen being required.

Many examples can be cited of extremely slow oxidation and of oxidation once started which has practically stopped from the absence of water; noticeable among which are the linen cloths wrapped about the mummies of Egypt, which have oxidized but little in four thousand years, and also the wooden mummy cases.

HYDROGEN PEROXIDE CAN MAKE A DEVELOPABLE IMAGE ON A PHOTOGRAPHIC PLATE

The hydrogen peroxide given off by substances undergoing automatic oxidation can make a developable image on a photographic plate in the dark, and the intensity of this image appears to be about proportional to the velocity of oxidation. Oils subject to spontaneous ignition are found particularly active.

INTENSITY OF IMAGE PROPORTIONAL TO RATE OF OXIDATION

In order to determine whether the intensity of the image on the photographic plate is proportional to the velocity of oxidation, I have taken samples of raw linseed, refined cottonseed, and lard oils and have measured the rate of absorption of oxygen by means of the decrease in the volume of air in contact with the oil for short periods at temperatures from 60 to 250 deg. fahr. The results of my experiments are shown in Fig. 1. In Fig. 2 are shown the impressions made on photographic plates by placing the oils near them in the dark.

The photographic plate undoubtedly indicates only the first stage in the automatic oxidation reaction, namely, the absorption of oxygen by the unsaturated oils and the formation of hydrogen peroxide.[2] It is apparent from the lack of parallelism between the curves in Fig. 1 for lard oil, linseed and cottonseed oil that the rate of absorption at low temperature is not proportioned to the so-called iodine values[3] for these oils. The lard oil, with an iodine value less than the cottonseed, absorbed considerably more rapidly up to about 230 deg. fahr. Also the impression made by the lard oil on the plate is stronger than that by the cottonseed oil, which has more than double the iodine value. The photographic plate can only be used at low temperatures.

HUMP IN OXIDATION CURVE AN IMPORTANT FEATURE

A feature worthy of careful notice with reference to the spontaneous-ignition hazard is the decided hump in the absorption curves of linseed and cottonseed oil at 100 deg. and 200 deg. fahr., respectively; also the fact that lard oil at ordinary temperatures absorbs oxygen more rapidly and acts on the photographic plate more strongly than cottonseed oil.

[1] Gesammelte Abhandlungen von Moritz Traube (Berlin, 1899), p. 400.

[1] Ibid., p. 403.

[2] Kritische Studien über die Vorgäng der Autoxydation, C. Engler.

[3] The iodine number of an oil is the percentage of iodine which it can absorb. It represents the amount of oxygen which can be absorbed, while the photographic image represents the rate at which the oxygen is absorbed, which is the important factor in spontaneous ignition.

From the absorption curve of cottonseed oil it would be expected that the spontaneous-ignition danger from this oil would not be great at temperatures below 150 deg. fahr., and that linseed oil could be used for almost any purpose with comparative safety against spontaneous ignition at temperatures below 80 deg. fahr., if kept out of the sunlight; also that lard oil would be more hazardous than cottonseed oil at room temperatures.

SUNLIGHT INCREASES THE RATE OF OXIDATION

A potent factor in increasing the rate of oxidation at room temperature is light, not necessarily ultra-violet light, but ordinary sunlight which has passed through several thicknesses of lead glass so that most of the light of shorter wave length has been removed. This at 80 to 85 deg. fahr. increased the rate of absorption of oxygen by cottonseed and linseed oils by about ten times, while with lard oil it apparently had less effect.

Oils painted on glass and maintained at 120 deg. fahr. for several days while being exposed to a photographic plate showed a stronger activity than other similar samples maintained at 65 deg. fahr., in about the proportion indicated by the oxygen-absorption curves.

COLLOIDS AND CATALYZERS FUNDAMENTAL IN PLANT AND ANIMAL PHYSIOLOGY

Automatic o idation and reduction at low temperatures are fundamental to the physiological reactions which go on in plants and animals, the mechanism by which these reactions are carried out being a combination of colloids and catalyzers. Gelatinous substances, starch and cellulose, act as the colloids, and iron and manganese compounds are chief among the catalyzers or carriers of oxygen. Dony-Henreault[1] has shown that many of the o idizing reactions given by organic compounds known as oxidases can be duplicated by a combination of gum arabic, which is a colloid, and minute quantities of manganese.

Sunlight is not only an important factor in increasing the rate of oxidation and photographic activity of oils, but also the photographic activity of wood. I have extracted what was apparently one or more of the materials causing this photographic activity from wood shavings, and the impression which this made on a photographic plate had an intensity about equal to that made by olive oil. Moderate heating increases photographic activity, while strong heating destroys it.

In the hard pines there are at least three different substances which can cause this activity, namely, turpentine, resin, and the water-soluble substance mentioned above.

SPONTANEOUS IGNITION OF CHARCOAL

Spontaneous ignition of wood is doubtless intimately associated with spontaneous ignition of charcoal, and this phenomenon has a much wider field of interest than would appear at first sight. In dwellings and factories numerous fires originate in the woodwork near steam pipes or other heating appliances which are maintained at temperatures far below the ignition point of wood, and are due to spontaneous ignition of charcoal formed by slow combustion over long periods.

[1] Bull. Acad. Royal Belg., Class de Science, 1907, p. 536, 1908, pp. 105-163; 1909, pp. 342-409.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee.

THE USE OF POWDERED COAL AS A FUEL

TO THE EDITOR:

The statement made in Mr. Harrington's paper on page 796 of the October number of The Journal, that "all the steam-making installations are in plants of the manufacturers of powdered-coal equipment, or in plants very directly connected therewith," is erroneous. It may be of interest to learn of a very successful installation for burning powdered coal under a boiler which has been in continual and regular service in the American Locomotive Company's Schenectady plant since March, 1915. This furnace is believed to be entitled to a world's record for low cost of maintenance.

The chart in Fig. 1 was taken from an ordinary day's

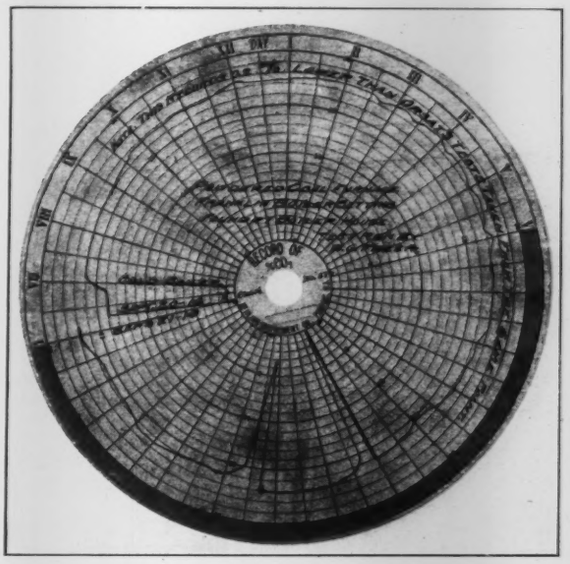


FIG. 1 CO_2 CHART OF POWDERED COAL INSTALLATION

run of this boiler, and shows that the CO_2 percentage rarely drops below 16 per cent and is oftener above 17 per cent. This recorder has been repeatedly checked by the Orsat apparatus, which gave 0.2 per cent higher CO_2, and sometimes indicated 18 per cent CO_2.

Several evaporative tests made by W. G. Freer, Mem.Am. Soc.M.E., showed that this extremely simple furnace, illustrated in Fig. 2, gave a materially higher evaporative efficiency than could be obtained from a duplicate Franklin boiler fired by mechanical stokers and supplied with feed water at the same temperature, and that it responded much more promptly to a sudden increased demand for steam than the adjoining stoker-fired boilers. An ordinary fireroom helper was readily taught to give the furnace all the attention ever required.

Previous to the installation of this furnace, between November, 1914, and March, 1915, several constructive revisions were made in a powdered-fuel furnace experimentally installed under the same boiler. Unfortunately, the brick arches and vertical walls completely failed to withstand the high-

temperature flames, and there were excessive accumulations of hard slag at the bottom of the furnace and deposits of unburned products around the tubes and in the gas passes.

Several years ago the writer concluded that the only way to prevent the destruction of vertical walls and arches in powdered-coal furnaces was not to have them, and substitute incandescent ignition surfaces formed by simple outwardly inclined walls which would be automatically maintained by a coating of protecting slag. After the failure of the vertical walls and the arches referred to, permission was granted by J. R. Magarvey, manager of the Schenectady works of the American Locomotive Company, to install the furnace shown in Fig. 2, which suggested itself, and is shown as originally installed. This furnace now has been in continual service for eighteen months without a single repair expense on the hopper-shaped furnace walls. These walls are coated with about 1 in. to 3 in. thickness of slag, and are seemingly in as good condition as at the time they were built. Only a small section of the old vertical wall which remained from the former furnaces was replaced at a cost of about five

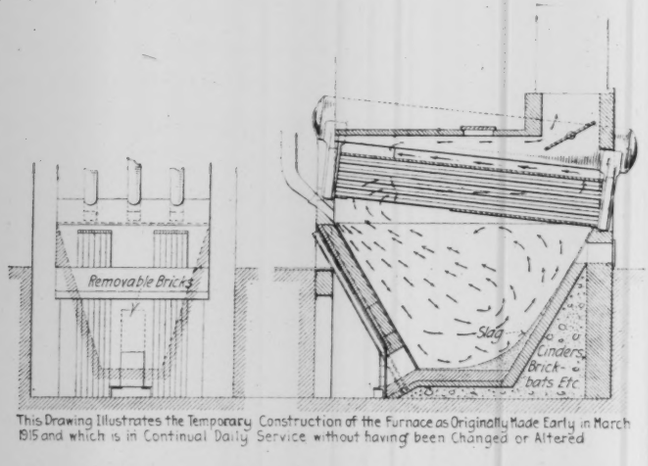

Removable Bricks
Slag
Cinders
Brick-bats Etc
This Drawing Illustrates the Temporary Construction of the Furnace as Originally Made Early in March 1915 and which is in Continual Daily Service without having been Changed or Altered

FIG. 2 POWDERED COAL FURNACE IN OPERATION SINCE MARCH, 1915

hours mason's labor; otherwise, there were no repairs with the exception of small fire-clay patches under the powdered-coal inlet tuyeres, which required about 30-min. work.

Fig. 3 shows the temporary construction of the 9-in. front slope wall which is supported by scrap boiler tubes. It has not been repaired since March, 1915. The fire pit openings are covered by temporary iron plates. Part of the brick were not laid in fire clay for convenience in removing for experiment. They were never removed since the installation.

The three original inlet tuyeres are yet in service and apparently may be in service for another year. This is particularly interesting, since they consist of three ordinary wrought-steel pipe nipples, 10 in. in diameter and 24 in. long, which, when originally installed, protruded downwardly a few inches into the furnace. After a short time the inner ends burned away and gave them their present form.

Powdered coal is fed by a screw feeder from a hopper into the air blast at a point about 3 ft. away from the furnace tuyeres. This distance may be very much more, but not less, for the purpose of thoroughly mixing the coal with a properly proportioned air blast that passes downwardly through the tuyeres at a pressure of ½ to 1½ oz.

A plurality of tuyeres and feeders is essential to good combustion, so as to reduce the effects of imperfect feeding of any one feeder or of flooding through a feeder from slips in the coal hopper. No particular form of feeders is necessary for successful operation. Fig. 4 shows a feeder set with eight outlets.

There is a very slight air inlet suction at the slag hole in the base of the furnace. In the furnace near the boiler the pressure is equal to atmospheric. In the gas passes the pressure is slightly less than atmospheric, an amount depending upon the resistance of friction to a flow of the gases into the uptake.

The lower row of water tubes was shielded by tiles for the purpose of giving sufficient heat-reflecting surface to maintain

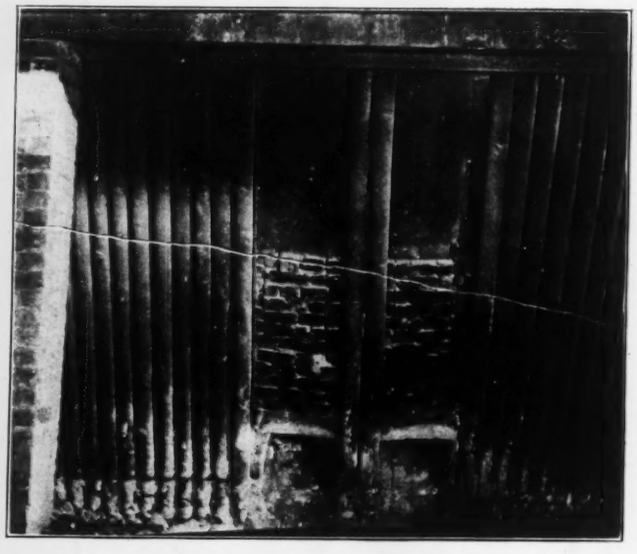


FIG. 3 CONSTRUCTION OF FRONT SLOPE WALL

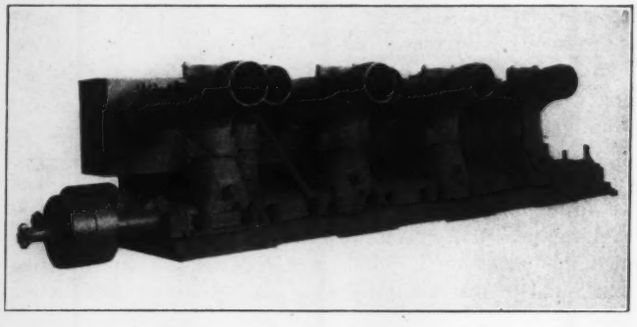


FIG. 4 POWDERED COAL FEEDER SET

the desired furnace temperature for the working capacity of the boiler. The amount of surface was determined by trial. During the first trial runs too many tiles caused an excessive furnace temperature and too strong an upward draft into the flue passes. On second trial, when for purpose of experiment nearly all the tiles were removed, the furnace temperature was too low. By several adjustments, Mr. Freer finally obtained the best results when approximately the lower back half of the water tubes was shielded as illustrated in Fig. 2. This amount of shielding gives ample freedom to the slowly upward flowing gases, and prevents all tendency to lift and deposit unconsumed fuel in the passes, which, therefore, do not require more cleaning than the passes in the adjoining mechanical-stoker-fed boilers. No trouble whatever is experienced

from coke or cinder-clogged water tubes; this is largely due to the hopper-shaped furnace, wherein all the downwardly jetted fuel and air from the three tuyeres is thoroughly blended and ignited in the confined space between the inclined and incandescent walls at the bottom of the furnace. Thereafter the resulting gases are permitted to freely expand as they slowly rise upward into the enlarged space under the boiler, in a manner which gives the flames a slow rolling movement from the bottom rearward, upward, then forward to meet the front end of the boiler, through the full length of a 30-ft. path, before coming in contact with heat absorbing surfaces. This insures perfect combustion, as indicated by the CO_2 diagrams.

CHARLES L. HEISLER.

Schenectady, N. Y.

WATER FLOW THROUGH PIPE ORIFICES

TO THE EDITOR:

Professor Judd's paper on Experiments on Water Flow through Pipe Orifices[1] has cleared up the whole subject of flow through orifices located in a continuous pipe and has explained many apparent inconsistencies of former experiments.

A consideration of the results can lead one to no other conclusion than that the moving particles of fluid form the equivalent of a venturi tube, and that the form of this is as definite as though it were confined by a solid casing; for other experiments to which the writer has access show the same coefficients of discharge, or, if another form of expressing it is preferred, corresponding pressure drops for such different fluids as water, steam, air and gas when the ratio of diameter of orifice to diameter of pipe and distances of connections are the same. This phenomenon is more obvious for the larger ratios of diameter of orifice to diameter of pipe, because for any given pressure drop the velocity of approach and energy of the fluid will be greater under these conditions. Also the surface of the moving stream and the amount of dead fluid compared to the volume of the jet will both be less, so that as the ratio of the diameter of the orifice to that of the pipe diminishes, the factors tending to break up and obscure this complete restoration of velocity head as static pressure increase very rapidly. It is found, however, with the velocities now common in practice that if it be desired to use one recorder for measurement with a number of orifices, the orifices show a comparatively narrow range of variation in ratio of diameter compared to diameter of pipe. This of course is reasonable, as fluid velocities are based on permissible pressure drop, which is a function of velocity and density, and of course varies with different classes of service.

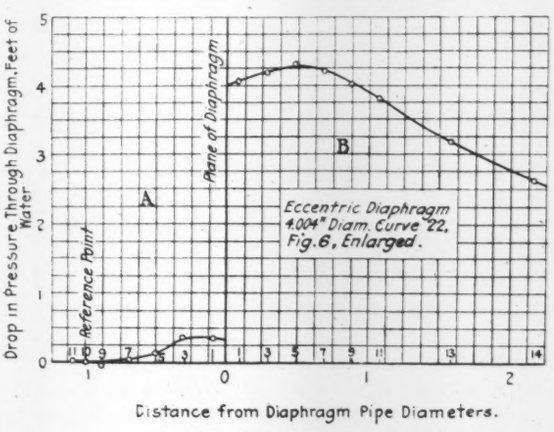


FIG. 1 REPRODUCTION OF FIG. 10, P. 714, THE JOURNAL, 1916

Professor Judd had an extremely difficult problem to plot his results so as to make it plain just what the curves represent, and in Figs 5 to 9, inclusive, he has taken the simplest method of showing the comparative readings at different ratios of flow. For the enlarged curves, for instance, Fig. 1, which is a reproduction of Fig. 10 of the paper, the writer prefers the curve plotted as shown in Fig. 2, everything being taken on the basis of pressure above or below that at A-10. In this way, if it is desired to ascertain the pressure drop between any two points it is only necessary to measure the total ordinate.

It seems curious that there should be a rise in pressure between the point A-10 and the orifice, but this is perhaps to be accounted for by the slowing up of a certain proportion of the fluid obstructed by the orifice and the transformation of the velocity of approach into static pressure. This reasoning is supported by the fact that the increase of pressure is most noticeable on the 90 per cent ratio orifice, less on the 80 per cent and almost disappears below the 70 per cent.

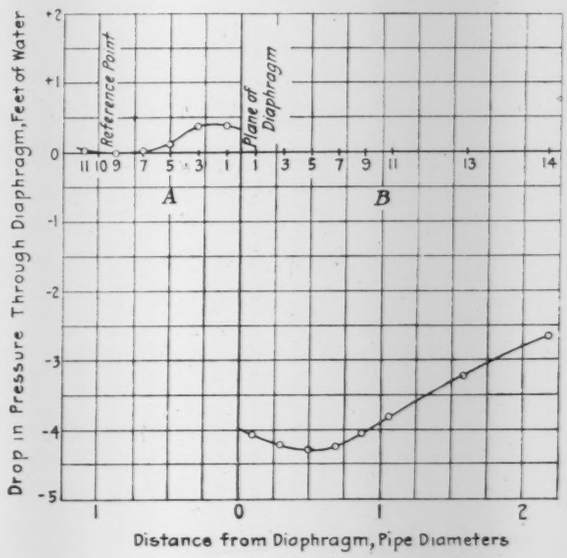


FIG. 2 PREFERRED METHOD OF PLOTTING CURVE SHOWN IN FIG. 1

H. D. FISHER.

Boston, Mass.

IMPACT OR SHEAR TESTS

TO THE EDITOR:

I should be glad to see a discussion in The Journal on the testing of materials by impact or shear.

The impact test on a notch bar has, of course, the objections that the notch cannot be held to great accuracy and that very small differences in it make a big difference in the results obtained. Attempts have been made to get away from this by substituting a shearing test, in which the foot pounds of

[1] Presented at the Spring Meeting of the Society, New Orleans, April, 1916, and published in THE JOURNAL, September, 1916.

energy required to shear are given, as measured by the travel of a pendulum.

Last June Mr. D. J. McAdam, Jr., gave a talk before the American Society for Testing Materials dealing with this, pointing out that it was very strange that ingot iron or very low carbon steel showed greater energy necessary to shear than did the higher grade chrome-nickel alloy.

This phenomenon has been known for some time, but, unfortunately, the deduction is made that, therefore, the lower carbon steel or ingot iron is less brittle and better able to resist shear. It must be remembered, however, in connection with this, that an energy diagram is really the measure of a rectangle, and a rectangle may have a long horizontal side or it may have a long vertical side. In the case of the chrome-nickel alloy steels, this rectangle has a long vertical side, and it requires a very much greater initial pressure to shear than does the other, but the areas are almost exactly the same.

In my paper on A Study of an Axle Shaft for a Motor Truck, which appeared in the June, 1915, issue of The Journal, it was pointed out that tests are nearly always made as to how to break a piece of steel, whereas the engineer really wants to know how not to break it. If such impact tests could be carried out in a way that the specimen be not broken, or, at any rate, not for a very long time, it would be found that the chrome-nickel alloy would probably resist the blows better than would the other. In other words, testing above the elastic limit is of little value to the engineer. Strength tests, etc., should really be made below the elastic limit, or, at any rate, what is known as the elastic limit.

JOHN YOUNGER.

Buffalo, N. Y.

SAFETY CODE FOR CRANES

TO THE EDITOR:

I submit the following suggestions regarding the Proposed Code of Safety Standards for the Operation of Cranes which is to be presented at the forthcoming Annual Meeting by the Sub-Committee on Protection of Industrial Workers, and which was printed in the November issue of The Journal:

6 *"Where Access to the Crane Is Necessary, Steps or Stairs with Hand Rails Should Be Used."*

Should also include "fixed ladders." This paragraph might well be omitted, as same subject is covered in more detail in Par. 8.

7 *"Platforms Should Be Provided for Changing and Repairing Truck Wheels on End Trucks and Provided With Stairways Leading to Them."*

This does not seem practicable, and in many cases would require extensive building-construction changes to allow room for the *"stairways."* Fixed ladders would take less room. Furthermore, in case of a breakdown, it might not be possible to move a crane to the repair platform.

10 *"Footwalks Should Be Placed Across the Ends of the Trolleys at Right Angles to the Bridge Walks and Shall Be Not Less Than Twelve (12) Inches in Width."*

The words *"where practicable"* should be put after the word *"placed."* It is obvious that many cranes cannot be so equipped.

14 (in part) *"Not Less Than Twelve (12) Inches Actual Clearance Should Be Allowed Between Highest Point of Crane and Overhead Trusses."*

While this is desirable, it is frequently impracticable on small cranes of a capacity of five (5) tons or less, and which are generally installed in or underneath galleries and in other places with low headroom.

24 *"The Installation of Switchboard, Wiring and All Electrical Equipment, Must Fully Comply With the Industrial Board Standards."*

The U. S. Bureau of Standards would be a better authority for rules for use in all states, than a Pennsylvania Board.

35 *"A Capacity Plate Showing the Maximum Capacity of Each Hoist in Pounds Shall Be Placed on Each Crane Girder in Such a Manner as to Be Clearly Legible from the Floor."*

Where a crane is located in the main bay of a building, a *"plate"* large enough to show the capacity legibly would be expensive to make, so would suggest re-wording that paragraph as follows:

"The maximum capacity of each hoist in pounds shall be painted, stencilled, or otherwise placed on each crane girder in such a manner as to be clearly legible from the floor."

37 *"Trolley Should Be Completely Floored."*

The meaning of this paragraph is uncertain and it should be re-worded to make the meaning clear.

The Rules for Operators, Floormen and Repairmen are identical, or nearly so, with the Rules for Cranemen which were issued by the National Founders' Association over a year ago and which have been found to be very satisfactory.

M. W. ALEXANDER.

West Lynn, Mass.

[These suggestions have been acted upon by the Sub-Committee on Protection of Industrial Workers and will be incorporated in the Code as presented at the Annual Meeting. —EDITOR.]

THE MEASUREMENT OF VISCOSITY

TO THE EDITOR:

Having read the paper of Messrs. Hayes and Lewis, and its discussion in the August issue of THE JOURNAL, the writer concurs with Mr. Hayes in his reply to the criticisms made, but would add the following comments:

Mr. Hayes misunderstands Mr. Bingham's phraseology in regard to the plasticity of suspensions, which refers to samples of suspensions under test, not to the torsion wire itself. Mr. Bingham's conception of the threshold stress below which plastic substances do not exhibit ordinary viscous flow, is an important one, more fully set forth in Bureau of Standards Scientific Paper No. 278.

The authors' treatment of the errors of short capillaries overlaps considerably the treatment previously published by Flowers in a paper of the same title.

In the course of experiments on the change in viscosity under pressure, made at Harvard University during the past year, the writer has employed a torsion viscosimeter of which the outer cylinder consists of an ordinary test tube. Thus 30 cc. is a sufficiently large sample; and the container need not be cleaned, for, in changing samples, one test tube is removed and another inserted. The inner cylinder is slim enough so that end effects are small, and, therefore, the instrument can be designed mathematically so as to have any desired characteristics. A brief account of this work will appear in the Journal of the Washington Academy, probably in an early issue, under the title The Theory of the Torsion and Rolling-Ball Viscosimeters, and Their Use in Measuring the Effect of Pressure on Viscosity.

The paper of Hayes and Lewis is one of the most sensible and useful papers relating to lubrication which have come to

the writer's attention; and especially so because of the vivid manner in which Figs. 6 and 7 draw attention to the fact, which ought to be more familiar than it is, that the viscosity scales of short capillary and orifice instruments are far from proportional to efflux times. Their second contribution, which they state is in preparation, is therefore much to be anticipated.

M. D. HERSEY.

Washington, D. C.

NOTES ON VISCOSIMETERS

TO THE EDITOR:

The original revolving-cup torsion viscosimeter seems to have been designed by Couette about 1890. The essential feature of this instrument, as distinguished from others of the same general type, is the use of stationary protecting caps over each end of the suspended cylinder to eliminate "end effects," thus rendering the calculations quite simple.

This is a high-grade scientific design, and, when properly constructed and operated, should be capable of giving exceedingly accurate results, expressed directly in C. G. S. units. However, owing to the high cost and the number of parts required, the instrument is hardly practical for general commercial use.

Several years ago the MacMichael viscosimeter was designed without previous knowledge of similar efforts along this line for practical use in a clay-working establishment. This instrument is quite simple in construction, is durable and is easily and quickly manipulated. One of these machines has been in constant use for several years, in the hands of unskilled laborers, and has given excellent service. Under these conditions readings ordinarily check within 1 per cent.

No attempt is made to calculate viscosities directly from measurements of the machine, as this would be extremely difficult, if not impossible. The method used is to calibrate the instrument with a standard testing sample of known viscosity, and assume that other readings are directly proportional in value. Through a wide range this does not seem to introduce serious errors.

For a standard testing fluid, a high-grade neutral mineral oil of high viscosity, such as some of the medicinal oils now on the market, is suggested, this oil to be supplied in metal containers by the U. S. Bureau of Standards, or some other recognized authority. The viscosity of these testing samples may be determined by means of the long capillary tube, which is sufficiently accurate for all practical purposes.

A cane-sugar solution of 7 parts by weight of sugar to 4 parts of cold water also gives good results. This should be tested after mixing, not depending on the weighed proportions to produce accurate results. Owing to its stickiness and tendency to form incrustations, this fluid is not so agreeable to use as an oil, but otherwise its properties are excellent.

In any type of instrument, whether capillary or torsional, a critical condition occurs at which turbulence takes place, and incorrect results are obtained. Reducing the speed, reducing the dimensions of parts, or increasing the viscosity of the fluid tends to check this action.

Also, in a freely suspended torsional instrument, at certain speeds and viscosities a pendulum-like oscillation of the suspended member occurs; this may increase rapidly and with violence, ruining the torsion wire unless checked. In the MacMichael instrument this is prevented by a suitably arranged, oil-filled dashpot, which also acts as a damper, to improve the general action of the suspended member.

The "spiral action" referred to in Messrs. Hayes and Lewis's paper, published in the August issue of The Journal, takes place also in the Hayes-Lewis machine, but as it occurs in a closed vessel it is not so easily seen. However, since this effect occurs equally with both the standard testing fluid and the sample being tested, and as the action itself is very moderate indeed, the errors introduced cannot be very serious. These spiral "end effects" are eliminated only in the Couette machine, as noted above.

The Hayes-Lewis machine appears to the writer to have neither the high-grade scientific features of the Couette instrument, nor the practical work-a-day features of some of the simpler designs.

Acknowledgment is hereby made of other torsional instruments recently brought to the attention of the writer, descriptions of which will probably appear in due time. However, none of these instruments seems particularly well adapted to general work, or to possess advantages over the models already described.

Torsion viscosimeters probably have an important field in colloidal chemistry, and in the measurement of suspensions, such as clay slips. Likewise, they are well adapted for the testing of oil under unusual conditions, such as at very high or very low temperatures. When properly built they are rapid, accurate, and easily manipulated. However, they are of necessity quite expensive, so that unless a very radical change occurs in public opinion, or a demand arises for a standard testing machine reading in absolute units, it is very doubtful whether they will ever supplant the short-tube commercial instruments now in general use.

R. F. MACMICHAEL.

Pittsburgh, Pa.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on November 10, 1916, in Cases Nos. 62, 90, 99, 100*c* and 104-112 inclusive. In this report, as previously, the names of inquirers have been omitted.

CASE No. 62

Inquiry: Is there no specific rule in the Boiler Code for determining the maximum distance to be allowed between tubes and rivets attaching crowfeet to the braced surface, similar to the construction used in horizontal return tubular boilers?

Reply: The maximum distance to be allowed between the edges of tube holes and the centers of rivets attaching crowfeet of braces to the braced surface should be determined as given in Par. 203 for determining the distance between centers of rivets attaching the crowfeet of braces to the braced surface, using 135 for the value of *C*.

CASE No. 87 (In the hands of the Committee)

CASE No. 90

Inquiry: Can the limitation of copper content in firebox boiler plate steel as prescribed in Par. 25 of the Boiler Code be increased or removed entirely? It is claimed that this can be done without affecting the safety or serviceability of the boiler.

Reply: Appeal for relief from this requirement was made by certain steel manufacturing interests. This appeal has received the support of the Association of American Steel Manufacturers, and several representatives of large users of boiler plate steel, including those with whom this portion of the specifications originated, have signified their willingness that this requirement be eliminated entirely. Definite action by the Boiler Code Committee is deferred until the general conference for consideration of revisions of the Code, to be held December 8 and 9, when all interested parties will have opportunity to be heard.

CASE No. 99

Inquiry: How shall the strength of angle irons used on the rear head below the tubes of a horizontal return tubular boiler be estimated in complying with Par. 201?

Reply: In calculating the strength of angle irons below the tubes in a horizontal return tubular boiler when used in pairs, if the outstanding legs of the two angles are fastened together so that they may act as one member in resisting the bending action produced by the load on the rivets attaching the angles to the head of the boiler, and provided that the spacing of these rivets attaching the angles to the head is approximately uniform, the angles may be figured as a single beam uniformly loaded and supported at the points where the through braces are attached.

CASE No. 100*c*

Inquiry: May a cast iron Y-fitting be used on a boiler and comply with the requirements of the Boiler Code?

Reply: A Y-fitting cannot be riveted to a boiler shell unless made of bronze composition, steel cast, or plate steel, in accordance with Par. 268 of the Code.

CASE No. 104

Inquiry: Is it permissible under the Boiler Code to use cast iron handhole plates? In view of the requirements of Par. 262, it would seem by inference that the use of such material is intended to be prohibited.

Reply: The Boiler Code does not prohibit the use of cast iron for handhole plates except for certain pressure and temperature limits as specified in the Code. (See Pars. 9 and 12.)

CASE No. 105

Inquiry: a. Is there a rule in the Boiler Code which covers the staying of conical surfaces smaller than 38 in. in diameter, as specified in Par. 231?

b. Is the surface of a cone top smaller than 38 in. in diameter that is stayed, better construction than an unstayed surface?

c. Will you advise the thickness of plate necessary for a cone 35⅝ in. in diameter at the bottom, 17 in. at the top, and 29½ in. in height, when no stays are used and the boiler is to operate at 125 lb. pressure?

d. Can the value of staybolts be added to the value of plate in determining the maximum allowable working pressure on a cone top less than 38 in. in diameter?

Reply: a. Yes. Conical surfaces requiring staying must be braced or stayed as flat plates in accordance with Pars. 199 and 212 of the Boiler Code.

b. The comparative value of unstayed plates and stayed plates is a matter for the manufacturer to determine by calculation according to rules given in the Code.

c. The plate thickness in this case should be determined by Par. 239, formula *a*.

d. No.

CASE No. 106

Inquiry: Must the longitudinal joint on the outer furnace sheet of a vertical tubular boiler, said sheet being properly stayed, comply with Par. 187?

Reply: The portion of the envelope of the boiler which is staybolted to the firebox sheet is not to be considered a part of the boiler shell referred to in Par. 187. The joint may be of less value and of a different type than that used on the barrel, but must result in a factor of safety of at least five.

CASE No. 107 (In the hands of the Committee)

CASE No. 108 (Annulled)

CASE No. 109

Inquiry: a. Will the usual form of double riveted joints apply for manhole reinforcement as required in Par. 260 of the Boiler Code?

b. Must Par. 182 be complied with in the arrangement of rivets for such a joint?

Reply: a. The arrangement of rivets commonly used on double riveted joints is permitted for manhole reinforcement.

b. The requirement of Par. 182 must be complied with in the design of such a joint.

CASE No. 110

Inquiry: Does Par. 317 of the Boiler Code require a check valve near the boiler and a valve or cock between the check valve and the boiler on each of the three feed connections to a three drum water tube boiler, or in the case of a battery of two boilers with three drums each, does it mean that each individual boiler shall have only one check and globe valve on the main feed pipe to each boiler?

Reply: Where a single boiler is concerned, one check valve and a valve and cock between the check and the boiler is all that is required. If more than one boiler is used, an additional globe valve placed outside the check valves on the branch to each boiler must be supplied, irrespective of the number of drums.

CASE No. 111 (In the hands of the Committee)

CASE No. 112

Inquiry: Is not a lap longitudinal joint on the shell of a type of boiler formed of concentric shells with radial fire tubes fitted between and expanded into the inner and outer shells and beaded over so that the tubes act as stays, in contradiction to the requirements of the Boiler Code?

Reply: A properly designed lap joint for the outer sheet, under the conditions named, where the outer sheet is properly stayed by the tubes, does not conflict with any requirement of the Code.

Society Affairs

Engineering Survey

Society Affairs Section ..... Page 1005
Engineering Survey Section .....Page 1029

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee on Cooperation in American Engineering Standards
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System, L. D. Burlingame
National Museum
Nominating Committee, Walter B. Snow
Patent Laws, Edward Weston
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam-Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Standards for Machine Tools
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit, M. E. Cooley, (Secretary not appointed)
Indianapolis, (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

---

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

COUNCIL NOTES

A MEETING of the Council was held on November 10, at which the following were present: D. S. Jacobus, *President;* John H. Barr, W. F. M. Goss, Arthur M. Greene, Jr., Frederick R. Hutton, W. B. Jackson, Charles T. Main, H. de B. Parsons, J. E. Sague, Jesse M. Smith, E. H. Whitlock, R. M. Dixon, *Chairman of the Finance Committee,* Calvin W. Rice, *Secretary,* and, by invitation, I. E. Moultrop, *Chairman of the Publication Committee.*

Boiler Code Committee. Interpretations of this Committee Nos. 62, 87, 90, 99, 100*c* and 104 to 112 inclusive were approved with slight corrections and ordered published. They appear elsewhere in this issue of The Journal.

The Journal. It was voted to approve an additional appropriation for the development of The Journal in accordance with the recommendation of the Publication and Finance Committees. These recommendations are published in the Report of the Publication Committee, which appears elsewhere in this issue.

Condensed Catalogues. A year ago the Council voted to discontinue the annual volume of Condensed Catalogues at the earliest practicable moment. Since that time, however, many members have expressed themselves as in favor of continuing the publication of this volume on account of its utility.

It was voted at this meeting that the question of continuance of Condensed Catalogues should be referred to letter ballot of the membership.

Committee on Filter Standardization. The report and recommendations of this committee were received and ordered printed. It will be distributed with other reports at the Annual Meeting and also published in The Journal.

The appointment of Prof. H. B. Langille as Honorary Chairman of the University of California Student Branch was announced by the President.

American Association for the Advancement of Science. An invitation from this Association for a joint meeting of its Engineering Section and the national engineering societies during the week of December 28, 1916 was accepted, and Dr. D. S. Jacobus and Mr. W. B. Jackson and the Society's representatives on the Advisory Council of the A.A.A.S. were requested to coöperate with the chairmen of the Committee on Meetings and of the New York Local Committee in carrying out the program.

CALVIN W. RICE,
Secretary.

SECRETARY'S CHAT WITH THE MEMBERS

THE President and the Secretary have had the privilege during the last month of visiting a number of the Sections and Student Branches of the Society. The enthusiasm in all places is magnificent and indicates that there is a movement on foot in the whole engineering profession which presages everything that is good for our profession and is a source of inspiration to the officers of the Society.

The most remarkable one feature of each of these gatherings is the spirit of coöperation. We are indebted to the work of the Industrial Census for bringing us in contact with the chemists, and we trust that they are now joined for all time with the engineers in all coöperative work for the good of our country and society generally.

It has been said more than once that the capacity for coöperation with respect to a nation is the gage of its civilization. What has, therefore, been said of the nation could be said probably with equal truth of a lesser organization.

In England, Sir Robert Hadfield, Mem.Am.Soc.M.E., Past-President of the Iron and Steel Institute of Great Britain, is proposing a scheme for increasing the scope of usefulness of the Institute, and similarly in Germany there has already been instituted an association of all the technical and scientific establishments of the German Empire, including engineers, architects, chemists, numbering in all sixty thousand, to such a degree that a Central European Institute is now contemplated. These coöperative movements in England and in Germany obviously have as their motives the protecting of the industries of the nations represented.

We, on our part, should not only protect the industries of our country for the benefit of the industries themselves, but our fundamental motive should be that after having protected and developed those interests we should devote them to the benefit of mankind. There is nothing inconsistent with the self-development and devotion to good works. Preparedness is the best insurance for peace.

The members of the societies brought together by Mr. W. L. Saunders, Mem.Am.Soc.M.E., to consider the formation of an organization of engineers and chemists which could bring its influence to bear on subjects of a civic character in which the profession is interested has resulted in the creation of an Organization Committee, of which the writer is secretary. Another meeting has been held, and a report of progress made to the officers and council of the societies participating in the Industrial Census. Included in this report of progress is a suggested form of organization, at present called, for lack of a better name, the Civil Scientific Alliance.

In the writer's individual opinion the scope of the present societies preferably should be enlarged, in distinction from forming a new organization to undertake civic work. The writer has corresponded with a large number of the officers of the Society and the Chairmen of its Sections and others throughout the United States and finds almost unanimous agreement with this view.

As a direct recommendation, and which expresses the earnest desire of the Council, the members of our Society in all parts of the world are encouraged to organize Sections of the So-

ciety, each section to be formed with the co-existing thought that it is to be only one of a group of sections, each representing some branch of the profession. These several groups, in turn, should be brought together under the auspices of some local engineering society, that organization to provide for the development of the professional spirit in the community. Of course, it is understood that in sparsely settled portions of the world these organizations cannot be obtained, and it may be that in some cases the members in several states will have to be brought together in order to form a section, in distinction from a number of cities. On the other hand, where there are a number of large communities very close together, the demarcation of the territory becomes somewhat difficult, and patience and a spirit of coöperation will have to be exercised by the members to assist the Committee on Sections to determine how best to group the members in their respective sections.

In every movement for such sections the spirit should be—how can we best develop the professional atmosphere in our community and how can we make that serve the community, and one's benefit in membership in an engineering society will be in proportion to his contribution to this movement.

CALVIN W. RICE,
Secretary.

THE THIRTY-SEVENTH ANNUAL MEETING

NEW YORK CITY, DECEMBER 5 TO 8

THE success of the Annual Meeting will be measured entirely by the pleasure and benefit each member and guest who attends derives from it. After three months' work on the part of the Meetings Committee, taking care of the professional features, and the New York Section Committee, providing for the social events, all arrangements are satisfactorily completed. It remains for those who attend the meeting to take advantage of them, and to the extent to which they take such advantage will they be benefited.

The Society has now come to be a very large organization—its membership has doubled in six years, and is fast approaching the ten-thousand mark. Its headquarters are in the largest building of its kind in the world, which is also occupied by sister organizations as large as our own. It is natural, therefore, that members coming to the Engineering Societies Building for the first time will find themselves surrounded with unfamiliar faces. They can quickly overcome this by introducing themselves by emblem and by name to their fellow-members, who will, in their turn, appreciate such introduction. Name badges will be provided for all and may be obtained upon arrival at the registration desk; these, worn throughout the meeting, will furnish an effective means of identification and overcome the initial embarrassment of exchanging names. At every meeting many desirable acquaintances are formed, but unfortunately, due to the inertia of human nature, they do not usually materialize until toward the end of the meeting. As last year, an Acquaintanceship Committee has been appointed for each day, and the members of these committees will devote their especial attention to seeing that members get to know each other. The personnel of these committees, as well as of the Committee on President's Reception, Excursion Committee, Ladies' Reception Committee, etc., who will each take charge of their respective functions, will be found in the programs issued at the registration desk.

As last year, an Information Bureau will be maintained, located in a prominent place, where full particulars regarding any event may be obtained.

Below is given a brief account of the main features of the meeting, followed by the program. Members should note that all the gatherings will be informal.

OPENING FEATURES

Dr. D. S. Jacobus, who during his term in the highest executive office of the Society, has done much to promote the welfare of the organization and that of its individual members, a large number of whom he has met personally in the centers in which the Society's activities are established, will deliver his Presidential Address on Tuesday evening on the Relation of Education to Engineering. This will be given in the Auditorium of the building, and will be followed by a reception.

On Wednesday morning there will be a business meeting which all should make it a point to attend on account of the importance to every member of the Society that he keep informed on the business affairs of the Society and participate in their conduct. Junior and Student Prizes for the year will be awarded at this meeting.

This will be followed by a memorial meeting in honor of the memory of Dr. John E. Sweet, Past-President, Honorary Member and founder of the Society, who passed away on May 8, 1916.

Not only was Dr. Sweet a founder of the Society, but it may be said that he was also the founder of modern practice in machinery building in this country. He possessed an infallible intuition for mechanics; he had a wonderful appreciation of correctness in details, and his influence over men was remarkable.

Four years ago we commemorated his eightieth birthday by a dinner at the Annual Meeting, and many members of the younger generation had the special privilege of meeting him there. These will join with his "boys" who gathered with him year after year on the occasion of his birthday, and who now, feeling the loss of his endeared figure most of all, will pay this tribute to his memory.

PROFESSIONAL FEATURES

The technical papers to be presented and discussed at the eleven professional sessions are truly representative of the broad field of the Society's activities.

The main professional feature of this meeting will be the Valuation Session, which has been assigned to Thursday morning, and which all will have the opportunity of attending. The subject of valuation is a new one in the proceedings of the Society; it is a basic one to engineers, although it has received most discussion outside engineering circles. The session will appeal to a large proportion of the membership.

Special attention is called to the sessions under the auspices of Sub-Committees of the Committee on Meetings—the Railroad Session, the Gas Power Session, the Machine Shop Session, the Industrial Safety Session, and the Textile Session, and to the one in charge of the Boiler Code Committee.

As at previous meetings, those concerned with the problems of generation of power, as well as those engaged in the design and manufacture of tools and machinery, will find papers of interest to them. On account of the length of the program, papers of the nature of either of these are grouped into simultaneous sessions, and it remains for members to attend those sessions of first interest to them.

Comprehensive abstracts of papers to be presented were published in the November issue of The Journal and are continued in this issue. Pamphlet copies of any of the papers will be sent to members of the Society gratis upon application, in advance of the meeting. Written discussion of the papers is solicited, and should be sent to the Secretary before the meeting.

The following papers and reviews, also to be presented at the meeting, will be abstracted comprehensively in a later issue of The Journal.

ILLUSTRATED REVIEW OF THE WERKSPOOR MARINE DIESEL ENGINES

By Thomas O. Lisle

This paper reviews the results of six years' development of the Werkspoor Marine Diesel Engine. The firm of Werkspoor has to date completed the engines of twenty-four sea-going mercantile ships, representing a total of about 35,000 h.p.

Werkspoor was one of the first firms in the world to build Diesel-type engines on an extensive scale, having been building stationary motors of this class for over sixteen years. Despite this experience, and although they had also the benefit of about half a century's marine engine construction, their first attempts at building the machinery of motor ships were most modest. When the firm first turned its attention to marine Diesel engines, it decided that, unless the engine can be repaired in any port in the world where steam engines can be repaired, it is of no use to ocean-going ships. To this day they have adhered to this policy, consequently their engine is exactly similar to any of the marine steam engines.

The review will include illustrations taken from the engines of the twenty-four vessels constructed by the concern, showing how a number of important and distinctive features have been evolved.

THE DEVELOPMENT OF OUR FLEET AND NAVAL STATIONS

By William L. Cathcart

The author will give a rapid review of the broad subject of the development of our fleet and naval stations, a question of impelling interest to engineers. The topics he will consider are:

The Engineer a mighty factor in the sea power of our time.

Why we need a great Navy.

Our country is the richest, and, owing to its vast extent of coast line, the most vulnerable of all the great powers.

Strategic situation, Eastern coast.

The elements of naval strength are its ships and men and its shore stations. The location of these stations with regard to our possible battlegrounds of the future is of primary importance.

Strategic situation, Caribbean Sea.

Strategic situation, North Pacific Ocean.

The needs of our naval stations.

In the up-building and maintenance of our Navy, we need a large number of Navy Yards, with channels of approach dredged to full depth and with modern equipment for building and repairing both hulls and machinery of naval vessels.

The Passive Defense: Mines and Submarines.

For continuous effectiveness we need an almost completee reliance on a wall of mines and submarines for the defense of our shores. These weapons in turn require protection by shore batteries or the guns of a fleet.

How large should our Navy be?

Not for aggression, but to keep the peace, and to exert what Mahan called "the silent force of sea power," we need a great Navy.

Some Points as to Guns and Powders.

Modern battle ranges.

Is a vessel with twelve 14-in. guns more formidable at an 8-mile range than one with eight 16-in. guns?

Our Proposed Dreadnaughts.

The markmanship of our Navy.

A battleship is essentially but a mobile gun platform, and its ability to hit with that primary weapon, the gun, is virtually its sole reason for existence.

Fire-control methods.

The foundation of modern methods of Fire Control was laid by Rear Admiral B. A. Fiske of our Navy in his invention and successful application of the Telescopic Sight to naval guns in 1892.

Our Relative Naval Strength.

Admiral Fiske's Greeting.

There are no other men in the United States so immediately and directly powerful in developing the fleet and naval stations as the engineers. While the strategist estimates the general situation, and determines the application of the general principles of strategy to each situation as it arises; and, while the tactician handles the units of personnel and material in actual battle and in preparation for it, it is the engineer who provides the strategist and the tactician with the mechanism with which to carry out their respective and collective aims.

HEAT TREATMENT OF WROUGHT IRON CHAIN CABLE

By Frederic G. Coburn, W. W. Webster and E. L. Patch

Extensive investigations have been conducted at the Boston Navy Yard on methods for heat-treating power-forged chain cable, under the direction of Frederic G. Coburn, Naval Constructor. The work was done largely by W. W. Webster and E. L. Patch, assistant naval constructors and graduate students at the Massachusetts Institute of Technology.

All the chain cable for the Navy are made in the Smith shop of the U. S. Navy Yard, Boston.

Previous to July, 1914, this chain was hand-forged and came up to all requirements without heat treatment. At that time, however, the process of manufacture was changed by the introduction of power forging and test links repeatedly and consistently failed to come up to the required strength. The fracture almost invariably occurred across the welded quarter, not in the weld, and showed a rather coarse granular structure. The links showed little tendency to change shape and stretch before breaking, as did the hand-forged links.

It was evident that the unannealed links were too "stiff"; that is, while the material was strong enough in direct tension it was not ductile enough to get the full benefit of the tensile strength, on account of the shape of the link. Because of this stiffness, the shear across the bent quarter would reach its limiting value long before the direct stress. The annealing relieved this stiffness and produced a relation between the strength and ductility of the metal which greatly increased the strength of the link. It was evident that in order to obtain uniform and satisfactory results a systematic investigation of the whole subject of the heat treatment of wrought iron cable should be made to develop scientific methods to replace the cut-and-try methods formerly used.

Accordingly a complete laboratory was equipped for this purpose at the Navy Yard and systematic tests were conducted, first on the stock material used in the manufacture of chains and later upon links taken from the chains themselves. These tests included chemical analyses, tensile and impact tests, and metallographic examination. Preliminary to the tests on the full-sized chain links, large experiments were conducted on heat-treated specimens of the material.

The paper gives the results of several of these series of tests with conclusions.

THE DOWNFLOW TYPE OF STEAM BOILER

By John C. Parker

This paper describes the early experiments which demonstrated the possibility of circulating the water in boilers apparently contrary to the natural way, that is, downward rather than upward. From these there was developed the downflow boiler which was designed by the author and has been built by him for a number of years.

In the circulating system there are non-return valves which compel the circulation to proceed in the downward course and prevent reversal of the flow. The more the fire is forced, the more rapid is the flow through the tubes and the greater the steaming capacity.

Chief among the advantages claimed for the downflow principle is that the course of the water and steam are opposite to those of the flame and hot gases, consequently the hottest particles of each are in communication with the hottest particles of the other and there is a minimum difference of temperature between the adjacent particles of the two.

The tubes are formed into a number of vertical coils by connecting their ends together through junction boxes, and one of the special problems in the manufacture of this boiler was the design of these junction boxes. The paper describes these boxes, which are constructed of malleable iron.

An interesting feature of the boiler is that the changes in temperature from heating and cooling when cleaning and banking cause sufficient expansion and contraction to crack off large quantities of scale, and the force of the flow of the water and steam carries this scale out of the tubes and into the drum in which a pocket is provided to collect it.

Another interesting form of construction described in the paper is a double-ended design in which there are two furnaces back to back, the products of combustion from which unite and flow together through the same course as in a single-ended boiler. The advantage is that the entire floor space is utilized for grate surface, and at the same time long tubes and horizontal travel of the gases are retained. Several stations have been enabled to greatly increase their boiler capacity in this way without requiring any more boiler-room space.

AUTHORS OF THE PAPERS

The large number of papers this year makes them no less authoritative, as the following brief notes regarding authors will show:

Victor J. Azbe, Combustion Engineer, is at present in charge of the two modernly equipped boiler houses of the Anheuser-Busch Brewing Association, of St. Louis, Mo., containing boilers to the capacity of 12,600 h.p. He has given much time to the study of inefficiently operated boiler plants and to means for their improvement.

J. R. Bailey, Professor of Organic Chemistry, University of Texas, prior to his appointment spent several years in research work in European laboratories, receiving the degree of Ph.D. from the University of Munich. He has been a frequent contributor to domestic and foreign chemical journals, and in the course of his professional activities has done much water-analysis work both for the U. S. Government and for private clients.

Carl G. Barth, senior member of the firm of Carl G. Barth and Son, Consulting Engineers, Philadelphia, was one of the first engineers in the country to become associated with the late Frederick W. Taylor in the development of his system of factory management, and is at present actively engaged in installing that system in several important industries. Before taking up this line of work Mr. Barth spent some fifteen years as designer for several machine-tool builders in Philadelphia.

A. F. Batchelder has been connected with the railway department of the General Electric Company since its formation in 1895, serving respectively as engineer in charge of railway equipment repairs, designing engineer, and engineer of the railway locomotive department.

O. C. Berry, Assistant Professor of Experimental Engineering, Purdue University, since 1914, entered the employment of the Fairbanks-Morse Manufacturing Company, at Beloit, Wis., in 1906, where he became interested in gas-producer problems. Two years later he took up instruction work at the University of Wisconsin, where, as at Purdue later, laboratory facilities for investigation were placed at his disposal.

Geo. B. Brand, of the Remington Typewriter Works, Ilion, N. Y., for eighteen years has been identified with the development of typesetting and typewriting machines, and for a part of this time was in charge of cost and production at the Monarch Typewriter Works, Syracuse, N. Y.

L. P. Breckenridge, professor of mechanical engineering, Sheffield Scientific School, Yale University, since 1910, was previously engaged in engineering educational work at Lehigh University and the University of Illinois, being head of the experimental engineering laboratories at the latter institution, as he is now at Sheffield. His services in the capacity of expert are in much demand.

W. A. Buck was in the turbine research department of the General Electric Company in 1914. He was a fellow in steam and gas engineering at Kansas State Agricultural College from 1914 to 1916. He is now assistant instructor in steam and gas engineering at the Kansas college.

F. G. Coburn, Naval Constructor, U. S. N., now located at the U. S. Navy Yard, Boston, Mass., has been continuously in charge of navy-yard shop production, both at Mare Island and Philadelphia, since 1908. He has given much attention to management problems and introduced the task-and-bonus system of wage payment in the Philadelphia yard.

Robert F. Earhart, Professor of Physics, Ohio State University, has conducted numerous investigations, principally in the field of pure science. He collaborated with S. S. Wyer in preparing a paper entitled Deviation of Natural Gas from Boyle's Law, which was presented at the 1916 Spring Meeting of the Society.

W. S. Finlay, Jr., now Construction Engineer, Motive Power Department, Interborough Rapid Transit Company, and in charge of mechanical design and construction, has been engaged in similar work since 1904, barring the period 1910-1915, in which year he first became associated with the Interborough Company.

Henry L. Gantt, Consulting Engineer, was associated with the late Frederick W. Taylor in the initial stages of development of the latter's system of industrial management, and for more than ten years past has given his professional attention to administration, management, and other subjects which confront the industrial engineer. He has presented many valuable papers on management and kindred topics before the Society, and has otherwise embodied his ideas in published works that have become a part of the authoritative literature on the subject.

H. K. Hathaway entered the employment of the Midvale Steel Company at about the time the late Frederick W. Taylor was beginning the reorganization of the production methods and management of that concern, and has since been almost continuously connected with the development and extension of the Taylor system, giving much attention to its application in machine shops.

Frederick J. Hoxie has been Engineer and Special Inspector of the Associated Factory Mutual Insurance Companies, Boston, Mass., since 1907. Previous to that time he had about fifteen years of varied engineering experience, much of it involving work of an experimental nature.

E. F. Maas, in charge of machinery, electrical and ordnance drafting at the Puget Sound Navy Yard, has had 15 years' experience in the design of rolling-mill and marine machinery, and has given special attention to the latter.

Sanford A. Moss, Engineer in charge of the Turbine Research Department of the General Electric Company, during the course of his extended connection with that company has carried out a number of important investigations dealing with the mechanics of fluids and of rotating machine members, some of which have formed the subjects of papers presented by him before the Society.

John G. Morse, Chief Appraiser of the Associated Factory Mutual Fire Insurance Companies, has been engaged for more than 15 years in making insurance appraisals of industrial plants. The development of the present method of making rapid, complete and accurate appraisals is largely due to his efforts, and he has applied this system successfully to some of the largest textile, metal-working, paper- and rubber-manufacturing plants in the country.

John E. Muhlfeld, since graduation from Purdue University in 1893, has been almost continuously engaged in railway motive-power engineering, rising to the position of General Superintendent of Motive Power, Baltimore & Ohio Railroad. In 1911 he was made Vice-President and General Manager of the Kansas City Southern Railway. In the course of his work he has brought out original designs of heavy locomotives of different types, of passenger and freight cars, of power plants, etc.

Geo. A. Orrok from 1898 to the present year with the New York Edison Company and latterly its mechanical engineer, has given much attention to the subject of surface condensation, his researches in this line having formed the basis of several important papers presented before the Society and of numerous contributions to the technical press.

John C. Parker, General Manager of the manufacturing company bearing his name, has since 1897 been continuously engaged in the design, development and manufacture of the particular type of steam boiler described in his paper. Prior to that date his engineering interests centered on steam and gas engines.

G. Hawthorne Perkins has been head of the textile engineering department of the Lowell (Mass.) Textile School for a number of years. Prior to his assumption of the position, he devoted his attention to mill engineering and the design of textile machinery.

Charles Piez, President and Treasurer of the Link Belt Company, Chicago, entered the employ of the Link Belt Engineering Company, Philadelphia, in 1885 as draftsman, rising to the positions of general manager and chief engineer in 1906. Three years later he became president of the corporation with which he is now identified.

Reginald J. S. Pigott, now Power Engineer of the Bridgeport (Conn.) Arms Works of the Remington Arms-Union Metallic Cartridge Company, was for ten years connected with the Interborough Rapid Transit Company, of New York City, in the respective capacities of assistant engineer and mechanical construction engineer, where he was in charge of the design and construction of power stations, of tests and investigations of engines, turbines, stokers, etc., and of the calculation, layout, and installation of low-pressure turbines. His later work included the preliminary design and layout of the extension of the 74th Street power station for the 30,000-kw. units recently installed.

Walter N. Polakov during the past ten years has had a wide practice as consultant on power-plant operation and factory management. His earlier engineering experience was acquired in a number of Russian works of varied character.

Andrew A. Potter, Dean of the Division of Engineering and Professor of Steam and Gas Engineering, Kansas State Agricultural College, has been connected with that institution since 1905. In the two preceding years he carried out a number of thermodynamic investigations dealing with steam turbines and superheated steam in the laboratories of the General Electric Company. During his present incumbency he has done much consulting work along steam and gas engineering lines.

Arthur D. Pratt has been connected with the Babcock & Wilcox Company for the past ten years, serving in the latter half of that period as Assistant to the Advisory Engineer. He has specialized in superheater and economizer performance and in the laws governing heat transfer, and during the past few years has given particular attention to the utilization of waste heat and the development of the modern waste-heat boiler.

Donald B. Prentice, with the exception of one year spent in outside work, since his graduation from Sheffield Scientific School, Yale University, in 1910, has been assistant instructor in the mechanical engineering department of that institution.

Herbert B. Reynolds, Assistant Engineer, Motive Power Department, Interborough Rapid Transit Company, New York, for the past three years, has given much attention to testing and research work on boilers, turbines and air compressors in his previous connections with the Westinghouse and General Electric companies.

Henry G. Stott, since 1908 Superintendent of Motive Power, Interborough Rapid Transit Company, and New York Railroad Company, held a similar position with the Manhattan Railway Company for some years, prior to which he was engaged for some ten years in the construction and operation of electric-light plants.

Arthur N. Sheldon was graduated from Lawrence Scientific School, Harvard University, in 1899, and since that time has been connected in various capacities with the firm of F. P. Sheldon and Sons, Engineers and Architects, Providence, R. I.

Dr. Arthur C. Scott, President of the Scott Engineering Company, Dallas, Texas, has been engaged in consulting work in general engineering for the past ten or more years, and in the course of his practice has given considerable attention to water problems of the Southwest. For several years prior to 1911 he was professor of electrical engineering at the University of Texas.

Philip W. Swain, Instructor in Mechanical Engineering, Sheffield Scientific School, Yale University, was graduated from Syracuse University in 1911 and received the degree of M. E. from Yale in 1915. In addition to his classroom and laboratory instruction work he has found time to carry out considerable commercial research work in various lines.

Paul A. Talbot, president of the Talbot Boiler Company, New York, had his attention drawn to boiler problems at about the time of the Klondike gold rush, and in succeeding years carried out many experiments to determine the advantages to be gained by rapid forced circulation. The prototype of the boiler described in his paper was brought out in 1907, since which time Mr. Talbot has given his entire time to its development and manufacture.

ENTERTAINMENT FEATURES

The members' get-together, get-acquainted, have-a-good-time smoker, so successful last year, will be repeated. This will be held on Wednesday night on the fifth floor of the Engineering Societies Building, where there is now ample accommodation for the large attendance expected. Frank P. Gilbreth, Mem.Am.Soc.M.E., will give a talk on his experiences in Europe during the war.

Luncheons for members and guests will be served on Wednesday and Thursday at noon, also on the fifth floor. A charge of 50 cents per person will be made.

A popular lecture will be delivered in the Auditorium on Thursday evening, and this will be followed by the annual reunion and dance, given on the fifth floor. Tickets will be issued for the latter, and it will be necessary to secure these in advance at the registration desk.

Excursions have been arranged to points of exceptional interest in New York and vicinity. Times and places will be announced in the program given out at the meeting.

The ladies will be entertained at a musicale and tea on Wednesday afternoon.

A number of colleges in the vicinity of New York will hold reunions on Friday night. To these the members of the Society are invited. Particulars are given elsewhere in this issue.

PROGRAM OF THE ANNUAL MEETING

Tuesday, December 5

CONFERENCE OF LOCAL SECTIONS. Luncheon of the official delegates from the Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, Minnesota, New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester, and the members of the Council of the Society. This will be followed by a business meeting to discuss plans of Section activities.

Registration Bureau opens 12 noon.

Council Meeting, 2 p.m.

Meeting of Sub-Committee on the Protection of Industrial Workers, 2 p.m.

Tuesday Evening

PRESIDENTIAL ADDRESS AND RECEPTION

Presidential Address by Dr. D. S. Jacobus, President of the Society, on the Relation of Education to Engineering. This will be followed by the annual report of the Tellers of Election of Officers, the introduction of the President-elect, and a reception to the President, President-elect, ladies, members and guests. This gathering will be informal.

Wednesday Morning, December 6

Morning sessions begin at 10 a.m. and afternoon sessions at 2 p.m. throughout the meeting.

OPENING SESSION

Business Meeting.

Reports of the Council, Standing Committees and Special Committees, Constitutional Amendments and new business.

Award of Junior and Student Prizes.

JOHN E. SWEET MEMORIAL

The regular business of the first session will be suspended at 11 a.m., when there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society.

MISCELLANEOUS SESSION

THE PROPORTIONING OF SURFACE CONDENSERS, George A. Orrok, Mem.Am.Soc.M.E.

THE TESTING OF HOUSE-HEATING BOILERS, L. P. Breckenridge, Mem.Am.Soc.M.E., and D. B. Prentice, Jun.Am.Soc.M.E.

WATER FOR STEAM BOILERS—ITS SIGNIFICANCE AND TREATMENT, Arthur C. Scott, Mem.Am.Soc.M.E., and J. R. Bailey.

The following eight papers will be presented by title without discussion at the meeting. Written discussion is solicited for publication and should be received by January 1.

STEAM SAFETY VALVES, George H. Clark
Contributed by the Boston Section

EFFICIENCY OF PROPULSIVE MACHINERY AND LATE DEVELOPMENTS IN NAVAL ENGINEERING, H. C. Dinger
Contributed by the Philadelphia Section

STANDARDIZATION OF POWER PLANT OPERATING COSTS, Walter N. Polakov, Mem.Am.Soc.M.E.
Contributed by the New York Section

TESTS OF 30,000-KW. TURBINE, H. G. Stott, Mem.Am.Soc.M.E., and W. S. Finlay, Jr., Mem.Am.Soc.M.E.
Contributed by the New York Section

THE DESIGN AND TEST OF A LARGE RECLAMATION PUMPING PLANT, G. C. Noble
Contributed by the San Francisco Section

BEARING LUBRICATION, Boynton M. Green

AN INVESTIGATION OF THE DYNAMIC PRESSURE ON SUBMERGED FLAT PLATES, Howard E. Stevens

THE ADAPTABILITY OF THE INTERNAL COMBUSTION ENGINE TO SUGAR FACTORIES AND ESTATES, M. Adam

INDUSTRIAL SAFETY SESSION

Under the auspices of the Sub-Committee on Protection of Industrial Workers

REPORT ON SAFETY STANDARDS FOR THE OPERATION OF CRANES

Wednesday Afternoon

MISCELLANEOUS SESSION

THE UTILIZATION OF WASTE HEAT FOR STEAM-GENERATING PURPOSES, Arthur D. Pratt, Mem.Am.Soc.M.E.

GRAPHIC METHODS OF ANALYSIS IN THE DESIGN AND OPERA-

TION OF STEAM POWER PLANTS, R. J. S. Pigott, Assoc-Mem.Am.Soc.M.E.

POWER PLANT EFFICIENCY, Victor J. Azbe, Jun.Am.Soc.M.E.

TEXTILE SESSION

Under the auspices of the Sub-Committee on Textiles

HEAT TRANSMISSION THROUGH VARIOUS TYPES OF SASH, Arthur N. Sheldon, Mem.Am.Soc.M.E.

SPONTANEOUS IGNITION STUDIED BY MEANS OF PHOTOGRAPHIC PLATES, Frederick J. Hoxie, Mem.Am.Soc.M.E.

VIBRATIONS IN TEXTILE MILL BUILDINGS, G. H. Perkins, Mem. Am.Soc.M.E.

MACHINE SHOP SESSION

Under the auspices of the Sub-Committee on Machine Shop Practice

STANDARDIZATION OF MACHINE TOOLS, Carl G. Barth, Mem. Am.Soc.M.E.

A PROPOSED PLAN FOR THE ACTIVITIES OF THE MACHINE SHOP SECTION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, H. K. Hathaway, Mem.Am.Soc.M.E.

CONFERENCE OF LOCAL SECTIONS—Meetings of official Section's delegates with officers of sections of sister societies.

During the afternoon a Musicale and Tea will be given in the rooms of the Society to the visiting ladies, members and guests under the auspices of the Ladies' Committee. This will be one of the important social features of the Annual Meeting and all are cordially invited to attend.

CONFERENCE OF STUDENT BRANCHES.

Wednesday Evening

SMOKER

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. Entertainment will be provided, and a feature will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., on his experiences in Europe during the war.

Thursday Morning, December 7

VALUATION SESSION

ACCURATE APPRAISALS BY SHORT METHODS, J. G. Morse

RELATION BETWEEN PERPETUAL INVENTORY VALUE AND APPRAISAL VALUE, Charles Piez, Mem.Am.Soc.M.E.

Thursday Afternoon

SECOND VALUATION SESSION

VALUATION OF INDUSTRIAL PROPERTIES VS. VALUATION OF INDUSTRIAL METHODS, Walter N. Polakov, Mem.Am.Soc.M.E.

PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PROPERTY, H. L. Gantt, Mem.Am.Soc.M.E.

CONFERENCE OF LOCAL SECTIONS—Meeting of official Section's delegates with Committee on Increase of Membership.

EXCURSIONS

Instead of providing for a large number of excursions, as in previous years, the New York Local Committee has arranged for a few of exceptional interest. Announcement of excursions will be made in the final program issued at the meeting.

GAS POWER SESSION

Under the auspices of the Sub-Committee on Gas Power

A GAS PRODUCER FOR BITUMINOUS FUEL, O. C. Berry

COMMERCIAL SAMPLING AND GAS ANALYSIS, P. W. Swain, Jun.Am.Soc.M.E.

AN INVESTIGATION OF THE INTERNAL-COMBUSTION ENGINE AS APPLIED TO TRACTION ENGINES, A. A. Potter, Mem.Am.Soc.M.E., and W. A. Buck

THE RATIO OF THE SPECIFIC HEATS AND THE COEFFICIENT OF VISCOSITY OF NATURAL GAS FROM TYPICAL FIELDS, Robert F. Earhart

ILLUSTRATED REVIEW OF THE WERKSPOOR MARINE DIESEL ENGINES, Thomas O. Lisle

Thursday Evening

LECTURE AND ANNUAL REUNION

The Committee has made arrangements for a Popular Lecture to be given in the Auditorium on Thursday evening.

Following the lecture, the members and guests are invited to adjourn to the fifth floor of the Engineering Societies Building for the Annual Reunion and Dance.

Friday Morning, December 8

MISCELLANEOUS SESSION

THE IMPACT TUBE, Sanford A. Moss, Mem.Am.Soc.M.E.

HEAT TREATMENT OF WROUGHT IRON CHAIN CABLE, F. G. Coburn, Mem.Am.Soc.M.E., W. W. Webster and E. L. Patch

THE FLOW OF AIR AND STEAM THROUGH ORIFICES, Herbert B. Reynolds, Jun.Am.Soc.M.E.

ILLUSTRATED REVIEW OF THE DEVELOPMENT OF OUR FLEET AND NAVAL STATIONS, W. L. Catheart, Mem.Am.Soc.M.E.

RAILROAD SESSION

Under the auspices of the Sub-Committee on Railroads

CLASP BRAKES FOR HEAVY PASSENGER EQUIPMENT CARS, T. L. Burton

PULVERIZED FUEL FOR LOCOMOTIVES, J. E. Muhlfeld, Mem.Am.Soc.M.E.

MECHANICAL DESIGN OF ELECTRIC LOCOMOTIVES, A. F. Batchelder, Mem.Am.Soc.M.E.

STEAM BOILER SESSION

Under the auspices of the Boiler Code Committee

AN ANALYSIS OF THE WORKING PARTS OF SAFETY VALVES MET WITH IN MARINE PRACTICE, WITH SUGGESTIONS FOR REPAIRS AND IMPROVEMENTS, E. F. Maas, Mem.Am.Soc.M.E.

THE TALBOT BOILER, Paul A. Talbot

THE PARKER BOILER, John C. Parker, Mem.Am.Soc.M.E.

Friday Afternoon

PUBLIC HEARING BY THE BOILER CODE COMMITTEE. This is open to all persons interested, and upon request special invitations will be sent.

Saturday Morning, December 9

PUBLIC HEARING BY BOILER CODE COMMITTEE CONTINUED.

JOINT "PREPAREDNESS" MEETING AT NEW LONDON

SATURDAY, NOVEMBER 11, 1916

THE members of the local Sections at Boston, New Haven, New York, and Worcester, members of the Providence Engineering Society, members of the Society at Meriden, Conn., and their friends, with guests from the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the Brooklyn Engineers Club, the New York Engineers Club, the Providence Engineering Society, the Philadelphia Engineers Club, the engineering alumni and students of Brooklyn Polytechnic Institute, Brown University, Columbia University, Massachusetts Institute of Technology, New York University, Stevens Institute of Technology, Worcester Polytechnic Institute, and Yale University, took part in a joint excursion on November 11 to New London, Conn., to inspect the plant of The New London Ship and Engine Company, manufacturers of Diesel engines, and to witness a special exhibition of U. S. submarines under the personal direction of Rear Admiral A. W. Grant, commander of the submarine forces of the United States.

The excursion was a success, but the opportunity attracted a much larger number than had notified the committees on arrangements, and while every officer did his best to take care of the unusual situation, the facilities provided, and even the resources which could be requisitioned at the last minute, proved inadequate. More than 1,600 took part in the excursion, which is more than have attended even the largest general meeting ever held by the Society, that of last December.

While all the members of the various parties were not able

"FREEDOM OF THE SHIP" ON THE BUSHNELL

to see everything they had anticipated, at least every one had a good day's outing and the opportunity for increasing his acquaintanceship. The weather—usually an important one of the large number of variables on an excursion of this kind—was perfect, which probably accounted for the general spirit of good nature that prevailed in spite of the overcrowded conditions.

According to the original plans, the five train contingents from Boston, New York, New Haven, Providence, and Worcester, together with automobile parties from other centers, were all to arrive in New London just before noon, all lunch at the Hotel Mohican, and all visit the plant and witness the submarine exhibition together. Sending out invitations to participate brought in so many applications for tickets, however, that these plans had to be replaced and, as still more applications came in, replaced again. The lunch capacity of

"A.S.M.E. SPECIAL" FROM NEW YORK ARRIVES

the Mohican was augmented by that of the Crocker House, and when this did not suffice two sittings were arranged at each, but when the time came even these were not ample, and several of the party had to get their lunch elsewhere.

In the same way the arrangements for boats to carry the party to the submarine exhibition were insufficient.

The party from New York left the Grand Central Station at 8:36 a.m. by a special train of eleven coaches. This party numbered 641. At New Haven two coaches were attached to the train, with 130 members and guests of the New Haven Section.

The party from Boston, numbering 300, left South Station at 8:29 a.m., also by special train. This stopped at Providence and took on 160 members and guests of the Providence Engineering Society.

The party from Worcester came by regular train, leaving Worcester at 8:36 a.m.; this party numbered 120.

Besides these train parties, a number of members and their friends residing in the vicinity of New London attended, bringing the total above the 1,600 mark.

Immediately on arrival the members proceeded to the respective hotels to which they had been assigned for luncheon, and, as already mentioned, those who could not be accommodated at these places were asked to make their own arrangements.

The following were guests of the Society at luncheon at the Hotel Mohican:

Rear Admiral A. W. Grant, Commander of the submarine forces of the United States.

Commander Yates Sterling, in charge of the U. S. Submarine Base at New London.

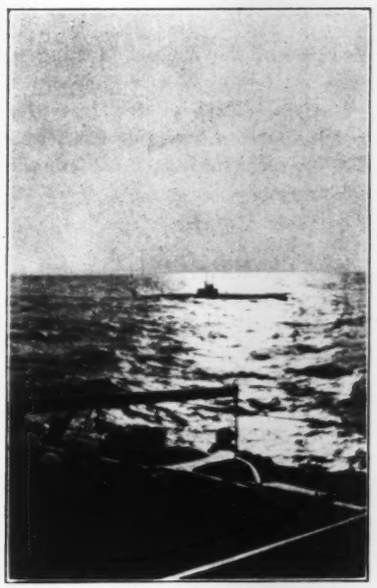
Commander John K. Robinson, in charge of the Naval Training Station at Newport.

Mr. Gregory C. Davison, Vice-President of The New London Ship & Engine Company.

Mr. Charles H. Bedell, Electrical Engineer, Electric Boat Company.

Hon. Ernest E. Rogers, Mayor of New London.

Following the luncheon, the party was taken on board the *U. S. S. Bushnell* and the *U. S. S. Fulton,* both submarine tenders, the army transport steamer *General Nathanael Greene* and the New London Company's Diesel engine ferries *Nelseco* and *Helys,* all of which were provided for the trip down the Thames. The vessels proceeded down the river, accompanied by five submarines—2 "D" type and 3 "L" type boats.



L-43 CLEARED READY TO SUBMERGE

On the way down the river the captains of the vessels allowed their parties the "freedom of the ship," and every facility was afforded to see everything on board.

The vessels steamed to a point off Fishers Island at the mouth of the Thames River, where the submarines gave an exhibition of submerging and diving, and the party returned.

Arriving back opposite New London, all those on the *Greene, Nelseco, Helys* and *Fulton* and about half of those on the *Bushnell* were taken to the plant of The New London Ship & Engine Company, across the river at Groton, Conn., where they were shown the processes of manufacture of Diesel engines for submarines of the United States Navy.

The New London Ship & Engine Company is building the "Nelseco" Diesel 4-cycle engines for both naval and commercial vessels in units of 60 to 3,000 h.p. in the 4-cycle reversible gear type, directly reversible type and double-acting type. The engines have been furnished for installation in United States submarines and in submarines of many foreign nations, as well as in commercial vessels on both the Atlantic and Pacific coasts and in foreign countries.

In addition to the Diesel engines, the company manufactures all machinery installed in submarine torpedo boats of the Electric Boat Co. type.

When this company was organized five years ago the first buildings were the office building, 102 x 71 feet, and the two-story machine shop, 165 x 105 feet. Since then each building has had additions made to it and other buildings have been erected, a notable point being the modern, sanitary construction, with every provision for light and ventilation and the best working conditions in all departments. Well-kept lawns with attractive flower-beds present an inviting appearance around the office building, which fronts the street and with its additions makes a three-story, perfectly appointed brick building of 101 feet frontage and two wings 154 feet deep.

To the rear of the office building and a short distance from it are the machine shop, pattern shop and storehouse, pipe shop, power house and other buildings.

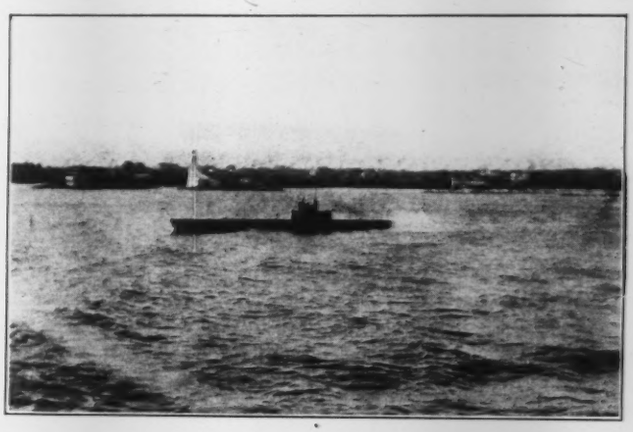
Successive additions to the machine shop, built of concrete and steel, have increased this to several times its original size, and it now is 600 feet long by 130 feet wide.

East of this is the store house and pattern shop, a wooden building, first built in 1911 and enlarged this year to its present size of 239 x 60 feet. Two pipe shops adjoin and connect with the machine shop on the west, furnishing the necessary facilities for this work in a building 204 x 65 feet.

Here also is the power house, first built in 1912 and increased in size this year to the dimensions of 93 x 112 feet.

At the southerly end of the plant is the new iron foundry, just completed and in operation in a building 178 x 85 feet. Adjoining this is the bronze foundry in a building 249 x 63 feet.

The time of the visit to the plant was particularly opportune, as the shops were full of work and engines of all sizes were on the testing floor. The party thus obtained a fairly representative idea of the processes and methods of construction of machinery for submarine service.



L-42 RUNNING ALONGSIDE THE BUSHNELL

The visitors returned to New London on the company's private ferry in time for their respective trains.

On the return train journey each member of the New York party was served with a box lunch.

We may well be optimistic regarding the future of our Society, and may well come to the realization of the growth of its Sections when we contemplate the overwhelming response to this Preparedness Excursion—without question the largest meeting of its kind ever held or likely to be held for some time to come.

Too much praise and appreciation cannot be given to the officers of the United States Navy and of the New London Ship and Engine Company (Electric Boat Co.) for the uniform patience they displayed and for the courtesy they extended to our members and guests.

PUBLIC HEARING ON BOILER CODE

Announcement has been made in the October and November issues of The Journal of a public hearing on the Boiler Code, commencing Friday, December 8, 1916, at 2 p.m., in the Engineering Societies Building, New York, and continuing on Saturday and into the next week if occasion requires.

This hearing is in pursuance of the following recommendation of the Boiler Code Committee to the Council:

> Your Committee recommends that you appoint a permanent Committee to make such revisions as may be found desirable in these Rules, and to modify them as the state of the art advances, and that such Committee should hold meetings at least once in two years at which all interested parties may be heard.

In view of several matters of considerable importance having arisen in connection with the revision period, a technical session of the Annual Meeting will be devoted to the Boiler Code Committee, at which three or more papers will be read that pertain to boiler questions under discussion. These are as follows: Safety Valves, by E. F. Maas; The Talbot Boiler, by P. A. Talbot, and the Parker Boiler, by John C. Parker. Another paper on the subject of the pencil electrode welding for boiler joints has also been offered. This session will be held Friday morning, December 8, beginning at 10 a.m., and it is hoped that all engineers interested in steam boiler problems and design will arrange to attend this session and discuss the papers.

The public hearing will follow immediately after this technical session on the boiler subjects and the Boiler Code Committee invites all who are interested in boiler subjects in general, and the A.S.M.E. Boiler Code in particular, will be in attendance and present their views.

SECTIONS' CONFERENCES AT ANNUAL MEETING

Those who have followed the affairs of the Society appreciate that our Sections are fast becoming one of the strongest elements in the life of our organization. Sections' meeting places are becoming the headquarters of the engineers in their vicinity. In their meetings the Sections are joining with the local branches of the other national organizations and are carrying out well the spirit of coöperation now dominant in the activities of the parent societies. They are contributing, through their meetings, valuable papers for the Society's publications. They are constituting a valuable medium for transmitting the influence of the Society to the mechanical engineering profession in various parts of the country. They are helping to increase the membership of the Society.

All the indications seem to justify the action taken by the Council two years ago, of inviting representatives from the Sections to come into personal contact with the Council and the management of the Society. With this end in view, the Society pays the railroad fare of one official delegate from each Section to each general meeting, and arranges conferences for the delegates.

These Sections' Conferences include "experience meetings," where delegates relate what their own Section is doing and hear what methods the other Sections are following. One meeting is held at which members of the Council are present; this is for the purpose of bringing the executive body of the Society into closer relationship with the membership.

The Conference at the coming Annual Meeting will begin with a luncheon at noon on Tuesday, December 5; the members of the Council will also be present at this luncheon. At 2 o'clock the first business session of the Conference will convene. On Wednesday, December 6, a second luncheon will be held, at which the officers of the sections of sister societies will be welcomed, and a second business session will be held Wednesday afternoon.

At the third luncheon on Thursday, December 7, the members of the Committee on Increase of Membership will meet the Sections' delegates and afterward join them in the discussion of matters of mutual interest.

STUDENT BRANCH CONFERENCE AT ANNUAL MEETING

One of the features of the Annual Meeting which has now become a permanent factor is the Conference of Student Branch representatives. Each of the forty Branches is invited to send a delegate to attend this Conference, which this year will be held on the afternoon of Wednesday, December 6, from 4.30 to 5.30 o'clock.

CORRECTION

Mr. F. P. Sheldon, author of the paper on Heat Transmission Through Various Types of Sash, calls attention to the following typographical errors in the abstract of this paper published in the November issue of The Journal:

Page 891, second column, line 8 should read "40 deg. *and* 70 deg."

Page 892, bottom of first column, "*Sample No. 2*" should read "*Sample No. 3*," and vice versa.

Page 893, first column, under *Proposition A, single-glazed steel sash*, "cost of heating system to supply *heating* loss only" should read "cost of heating system to supply *window* loss only."

Page 894, first column, fourth line under the heading "Internal Condensation in Double-Glazed Sash," delete "not."

LIBRARY NOTES

Dr. James Douglas, of New York, has presented $100,000 to the United Engineering Society, the income to be used for the benefit of the Library.

The Trustees of the Society have perfected plans for the development and the extension of the usefulness of this great Engineering Library and are endeavoring to secure endowments aggregating $1,000,000, the income to be used for the Library.

The plans of the Trustees having been submitted to and carefully examined by Dr. Douglas have been approved by him, and he has signified this approval by his gift of $100,000, which has just been made.

Now that the Library of the American Society of Civil Engineers has been united with the libraries of the Institutes of Mining, Mechanical and Electrical Engineers in the Engineering Societies Building, the combined library forms the greatest engineering collection in the world. It is the purpose of the Trustees to greatly extend its usefulness and it is hoped that the splendid endorsement which Dr. Douglas has given will stimulate other similar endowments until the necessary million dollars has been obtained.

REPORTS OF STANDING COMMITTEES

THE reports of Standing Committees for the fiscal year ended September 30, 1916, will be presented at the Annual Meeting as an appendix to the Annual Report of the Council of the Society's activities for the year. The Standing Committee reports are published below.

REPORT OF THE FINANCE COMMITTEE

The Finance Committee reports that the income of the Society for the year ending September 30, 1916, was $167,141.72. The total expenditures chargeable to income were $143,023.31, leaving an excess of income over expenditures of $24,118.41, this being a net balance after reserving $10,350.00 for obligations undertaken but not yet completed.

The expenditures of the Society per member for the fiscal year just closed are as follows:

General Salaries	$ 2.25
Headquarters, library, supplies, etc.	1.80
Committees on Membership and Increase of Membership	1.23
Sections	.90
Employment Bulletin	.23
Council contingencies	.41
House Committee	.24
Annual and Spring meetings	1.07
Year Book	.56
Journal and Condensed Catalogues	7.00
Transactions	2.08
Other activities	2.03
Making a total of	$19.80

The recommended Budget Appropriation for the year 1916-1917 is as follows:

Finance Com. Incl. Lib. Asst.		$32,400.00
Membership Committee		2,500.00
Council Contingencies	$2,000.00	
Mileage at 7c	2,000.00	
Employment Bul.	2,000.00	
		6,000.00
Sections		9,000.00
Inc. Membership Com.		6,500.00
House Committee—		
Depreciation	$2,500.00	
Other	975.00	
		3,475.00
Meetings Com.		9,000.00
Publication Com.		80,000.00
Research Com.		300.00
Student Branches		750.00
Junior Prizes		100.00
Sales Expenditures		10,000.00
John Fritz Medal		125.00
Total		$160,150.00

The estimated income for the year 1917 is $167,000.00.

The Committee takes pleasure in announcing that on July 1 last the Certificates of Indebtedness of the Society were paid and that the Society is out of debt.

Appended will be found reports of the accounts of the Society as shown in the book for the fiscal year ending September 30, 1916.

Respectfully submitted,

R. M. DIXON, *Chairman,*
W. H. MARSHALL,
GEO. M. FORREST,
A. E. FORSTALL,
Finance Committee.

REPORT OF ACCOUNTS

MR. R. M. DIXON,
CHAIRMAN, FINANCE COMMITTEE.

Dear Sir:

In accordance with your instructions we have examined the books and accounts of The American Society of Mechanical Engineers for the twelve months ended September 30th, 1916.

The results of this examination are set forth in the three exhibits, attached hereto, as follows:

Exhibit A Balance Sheet, September 30, 1916.
Exhibit B Income and Expenses for the twelve months ended September 30, 1916.
Exhibit C Receipts and Disbursements for the twelve months ended September 30, 1916.

We hereby certify that the accompanying Balance Sheet is a true exhibit of its financial conditions as of September 30, 1916, and that the attached statements of Income and Expenses, and Receipts and Disbursements are correct.

Respectfully submitted,
(Signed) WM. J. STRUSS & CO.,
Certified Public Accountants.

EXHIBIT A

BALANCE SHEET, SEPTEMBER 30, 1916

RESOURCES

Equity in Society's Bldg., (No. 25 to 33 West 39th St.)	$353,346.62	
Equity in 1-3 Cost of Land (No. 25 to 33 West 39th St.)	180,000.00	
		$533,346.62
Library Books	13,000.00	
Furniture and Fixtures	5,000.00	
		18,000.00
Stores, including plates and finished publications		20,051.67
Trust Fund Investment		
New York City 3½'s 1954 (par $45,000)	39,696.81	
St. Louis, Peoria & N. W. 1st 5's 1948 (par $10,000)	10,613.89	
United N. J. Canal Co. (par $1,000)	970.00	
Cash in Banks representing Trust Funds	6,568.71	
		57,849.41
Cash in Banks for General Purposes	44,283.43	
Petty Cash, on hand	500.00	
		44,783.43

Accounts Receivable		
Membership Dues	14,392.34	
Initiation Fees	2,005.00	
Sales of Publications, Advertising, etc.	27,336.93	
		43,734.27
Advance payments		2,907.14
		$720,672.54

LIABILITIES

Trust Funds		
Life Membership Fund	$45,343.81	
Library Development	4,902.71	
Weeks Legacy	1,957.00	
Initiation Fee	2,352.90	
Junior and Student Prizes	2,000.00	
Melville Fund	1,084.00	
Hunt Memorial	208.99	
		$ 57,849.41
Dues and Initiation Fees paid in advance	821.57	
Initiation Fees uncollected	2,005.00	
Unexpended Appropriation 1915-16	7,301,69	
Unapportioned Revenue	27,166.72	
		37,294.98
Capital Investment	551,346.62	
Surplus and Reserve	74,166.20	
		625,512.82
Annual Meeting Social		15.33
		$720,672.54

EXHIBIT B

INCOME AND EXPENSES FOR THE TWELVE MONTHS ENDED SEPTEMBER 30, 1916

INCOME

Membership Fees	$97,561.87	
Sales—Gross receipts	13,488.97	
Advertising	51,855.26	
Interest and Discount	4,235.62	
Total		$167,141.72

EXPENSES

Finance Committee		
Office Administration	20,344.77	
Occupancy Building	4,800.00	
Library	4,021.55	
		29,166.32
Membership Committee		2,366.82
Council		
Contingencies	2,050.44	
Mileage	975.10	
Employment Bulletin	1,645.78	
		4,671.32
Sections Committee		6,432.07
Increase of Membership Committee		6,498.70
House Committee		1,697.94
Meetings Committee		7,725.12
Publication Committee		
Advertising	26,703.23	
Journal Text	24,056.61	
Revises	335.90	
Transactions	15,668,83	
Year Book	3,988.72	
		70,753.29
Sales		
General	6,346.24	
Boiler Code	2,021.43	
Power Test Code	1,207.41	
Society History	1,004.00	
		10,579.08
Research Committee	232.28	
Students' Committee	787.02	
Junior Prize	59.96	
Library Service	250.00	
John Fritz Medal	3.39	
Engineering Congress	1,800.00	
Total		$143,023.31
Excess of Income over Expenses.		24,118.41

Note: The item of Total Expenses includes $10,350.00 not yet paid to complete work already in progress, chargeable to this year's activities.

EXHIBIT C

RECEIPTS AND DISBURSEMENTS FOR THE TWELVE MONTHS ENDED SEPTEMBER 30, 1916

RECEIPTS

Membership Dues	$96,332.85	
Initiation Fees	20,100.00	
Membership Dues paid in advance	1,327.32	
Sales of Publications, Badges, Advertising, etc.	67,488.86	
Interest	3,398.76	
City of East Orange Loan	20,000.00	
	$208,647.79	
Cash on hand and in Banks—General and Trust Funds, September 30, 1915	40,707.56	
		$249,355.35

DISBURSEMENTS

Disbursements for General Purposes	$143,903.21	
Certificates of Indebtedness redeemed	54,100.00	
	$198,003.21	
Cash on hand and in Banks—General and Trust Funds, September 30, 1916	51,352.14	
		$249,355.35

REPORT OF COMMITTEE ON MEETINGS

The attendance at the last Annual Meeting was the largest in the history of the Society, the total registration reaching 1,437. Seven sessions were held, of which four were in charge of sub-committees. There were 23 papers, exclusive of six from the Local Sections assigned to be read by title.

During the first session, there were memorial exercises in honor of the memory of our distinguished Past-President, Dr. Frederick W. Taylor. The other sessions were purely technical, one of which was on the general subject of industrial safety, now receiving attention throughout the country. The widespread interest in the various activities of the Society was evident by the numerous committee meetings throughout the Annual Meeting, including several conferences by local committees.

The smoker, held in place of the usual lecture on Wednesday evening, received general approval, but the large attendance badly overcrowded the Society's rooms. The chairman is pleased to report that the committee has since taken action which has resulted in the remodeling of the fifth floor of the Engineering Societies Building, with a new floor suitable for dancing.

The Spring Meeting at New Orleans, April 11 to 14, afforded an opportunity to visit a section of the country having distinctive engineering features, and the meeting, including the stop-over at Birmingham, was most successful. A notable feature was the discussion on Industrial Preparedness, which drew out many practical suggestions and valuable contributions from every part of the country.

Comparing the coming Annual Meeting with that of a year ago, we find that there will be eleven sessions, of which six are in charge of sub-committees. There will be 32 papers, exclusive of four from the local Sections to be read by title. One session designed to be of interest to the membership generally, has been arranged on The Valuation of Industrial Property. Following the regular business session there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society. This year for the first time the reunion and dance of Thursday evening will be in the Engineering Societies Building as a result of the remodeling of the fifth floor.

H. L. GANTT, *Chairman*,
R. H. FERNALD,
JOHN H. BARR,
L. P. ALFORD,
D. S. KIMBALL.

REPORT OF PUBLICATION COMMITTEE

The publications of the year have been The Journal, issued monthly, the annual volume of Transactions, the Year Book, the sixth annual volume of Condensed Catalogues, and the Power Test Code (reprinted from vol. 37 of Transactions).

THE JOURNAL

In its Annual Report for 1915, your committee made the following recommendations respecting The Journal:

That The Journal shall contain:

(*a*) All of the papers and discussions presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.
(*b*) Papers, or abstracts, with discussion, presented at meetings of Local Sections.
(*c*) Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.
(*d*) Department for contributed discussion on papers previously published, or new matter.
(*e*) Members' correspondence department, including suggestions on Society affairs.
(*f*) Review of world's technical press.
(*g*) Reviews of technical books, by experts selected by the committee.

In respect to the accomplishment of those recommendations, we have to report as follows:

(*a*) The papers and discussions presented at general meetings have been abstracted to approximately one-half of their original length, this being the largest fraction allowable under the existing appropriation.
(*b*) The Sections held about 100 meetings during the year, but the material presented at all of these was not of the nature for publication. As the result of our regular solicitation, from month to month, twenty-three papers were received from Sections; twenty-one were published in The Journal and two were held over on account of lack of space.
(*c*) The Society Affairs Section has averaged twenty-eight pages. The amount of material available for this department has increased steadily and material is now being held out for lack of space.
(*d*) and (*e*) The Correspondence Departments, started in January, 1916, are now quite pretentious. We are now averaging four contributions per issue.
(*f*) The scope of the Engineering Survey Section has been increased, but appropriations have not allowed development to the point of the committee's recommendation, *i.e.*, to cover the world's technical press. As a compromise, important articles not abstracted have been listed monthly.
(*g*) Appropriation has not been sufficient to undertake book reviews. Preliminary work for this department has been done, and the reviews can be started as soon as funds are available.

The scope of the Society's work has broadened so rapidly since the committee made its recommendations that we need to increase the scope of The Journal even beyond that recommended. We propose to now extend these recommendations as follows:

PROPOSED SCOPE OF THE JOURNAL

Technical Section.

Papers and Discussions presented at Spring and Annual Meetings and at Local Meetings.
Technical Correspondence, including brief original articles on subjects not related to papers and now precluded by lack of appropriation.
Technical Items of Interest. Pages or paragraphs from other publications referring to the subject-matter of the current technical section.
Summaries of Engineering Information, such as:
Lists of Books on certain subjects, such as those in the current technical section.

Synopses of Current Researches.

Lists and Synopses of Engineering Standards. This is greatly needed by engineers generally, and is matter so important and of such great magnitude as to require special provisions for its adequate handling.

Society Affairs.

Announcements, Reports of Meetings, Special Articles, such as Biographical Sketches. Committee Reports, Section and Student Branch News, Communications, Applications for Membership, Necrology, General Notes, etc., substantially as conducted now.

Engineering Survey.

Review of the World's Technical Literature, extended and improved as previously recommended by the Committee, and classified.
Selected classified lists of leading articles in current periodicals.
Reports, Synopses and Lists of Researches conducted by governmental, industrial and collegiate laboratories, to be secured by editorial staff by personal solicitation and from coöperation with the National Research Council.
Review of Important Events secured through the Local Sections and from regularly appointed correspondents, from individual members and from the technical and daily press.
Reports of Meetings of Engineering Societies closely related to the field of mechanical engineers, these reports to be prepared by representatives of The Journal in actual attendance at the meetings.

Miscellaneous Department.

Employment Bulletin.
Book Reviews.
Personals.
Library Notes and Accessions.

TRANSACTIONS

Volume 37 of Transactions, issued during the summer to standing members in 1915, was the largest ever published by the Society, containing nearly 1600 pages.

The volume recorded the affairs of the Society during 1915, and included a general review of the work of the Society for this year, given in the Annual Report of the Council. It contained a calendar of all the meetings of the Society—general meetings and local meetings—held during the year; and the papers, with discussion, presented at the Spring Meeting in Buffalo, April, 1915, the Annual Meeting in New York, December, 1915, and the additional general meeting in San Francisco, September, 1915, in connection with the International Engineering Congress 1915. Papers read at local meetings and presented subsequently at a general meeting were also included. The reports of special committees received by the Council during 1915 and ordered published were published in the volume; of special note among these is the report of the Power Test Committee.

THE YEAR BOOK

The rapid growth in membership of the Society has forced the Committee to again give attention to the problem of the size of the Year Book.

Six years ago, when the pocket list of members—the small-size Year Book—was adopted, the total membership in the Society was 3680; this allowed a volume of 310 pages, with an average of sixteen names on a page. At the present rate of increase of membership, the 1917 volume will contain nearly 8000 members.

The 1916 Year Book included an alphabetical register of 6931 names printed within the space of 254 pages, and a geographical list occupying 142 pages. This conservation of space was accomplished by using a condensed, but perfectly clear, face of type and by careful editing of entries and use of abbreviations.

The new arrangement will probably serve for two years more, when the Committee will have to again give consideration to the matter, as both further reduction in type and further abbreviation of words will sacrifice clearness.

CONDENSED CATALOGUES

The sixth annual volume of Condensed Catalogues contained data concerning the products of 267 firms, and a Classified Directory Section listing the products of 2500 manufacturers classified under 2000 different subject headings. The Engineering Data Section, a feature commenced in the 1915 volume, was continued, and contained 40 pages of data selected from Volume 37 of Transactions and from The Journal for 1915.

POWER TEST REPORT

As stated above, this report was included in the current volume of Transactions. Your Committee anticipated a large demand for copies of the report, and so had fifteen hundred reprints bound and issued as a publication of the Society. Over one thousand copies of this publication have been sold to date.

I. E. MOULTROP, *Chairman*,
FRED. R. LOW,
FRED. J. MILLER,
HENRY HESS,
C. I. EARLL.

REPORT OF MEMBERSHIP COMMITTEE

The Committee on membership held ten meetings during the year 1915-1916.

The number of applications considered in the transaction of its work and a summary showing the action taken, follows:

Applications pending Oct. 1, 1915	492
Applications received during fiscal year	1387
Total	1879

The following action was taken on these applications:

Recommended for membership	1143
Recommended for membership (special cases)	14
Deferred indefinitely	6
Deferred	14
Denied promotion	2
In regular course of procedure (seven of which are held for special investigation)	700
Total	1879
Reinstatements and Reconsiderations pending	9

Those recommended for membership were divided into the following gradings:

Members	371
Promotion to Member	58
Associates	37
Associate-Members	236
Promotion to Assoc.-Mem	46
Juniors	395
Total	1143

The reinstatement of sixteen members was recommended to the Council.

Under B 16, it was recommended to the Council that the dues of seventeen members be permanently remitted.

HENRY C. MEYER, JR., *Chairman*.
L. R. POMEROY,
HOSEA WEBSTER,
CHARLES E. LUCKE,
FRED J. MILLER.

REPORT OF RESEARCH COMMITTEE

A new *Sub-Committee for the Consideration of Bearing Metals* has been instituted, headed by Mr. C. H. Bierbaum as chairman. Prof. H. Diederichs and Mr. John A. Capp have been appointed on this committee.

The Centigrade Thermometric Scale and the Metric System. The question of the adoption of the centigrade scale, as proposed by a member of Congress, without the accompanying change to the metric system of other weights and measures, was referred to the Research Committee; the question was referred back to the Council with the recommendation that it be turned over to the Joint Committee on the adoption of the Metric System, together with the expressed opinion that such a change was absolutely undesirable, in that it would cause worse confusion than we have at present. It was pointed out that we have many advocates for both systems, the present weight of opinion being apparently in favor of the English system of weights and measures. As far as we are aware, no engineer would be willing to support a combination of the two.

The Sub-Committee on the Clinkering of Coal (Prof. Lionel S. Marks, *chairman*) has been suspended until the research which is at present under way by the Bureau of Mines and

the Bureau of Standards shall have been completed, which will take about another year.

The Sub-Committee on Flow Meters (R. J. S. Pigott, *chairman*). This committee has prepared a bibliography of their references and is making a compendium abstracted from the references. Experiments have been carried out on the relative accuracy of five commercial makes of flow meters; special tests being carried on in relation to the internal friction of recording mechanism and the peculiarities of the individual machines. As all of these meters (twenty-eight in number) are in regular service, operating records on the troubles with them are also being accumulated. The results of these tests, part of which will be made by the CO_2 method advanced by Mr. E. G. Bailey and part by a Thomas electric meter method, will be published during the year.

Sub-Committee on Fuel Oil (Prof. Danforth, *chairman*). This committee has prepared a questionnaire on the subject of fuel oil, which is at the present time about one-half completed.

Sub-Committee on Lubrication (Mr. Albert Kingsbury, *chairman*). A bibliography of the references on lubrication has been prepared.

Sub-Committee on the Cutting Action of Machine Tools (Mr. L. P. Alford, *chairman*). Correspondence has been taken up with the Bureau of Standards, but due to pressure of other work in the Bureau and lack of facilities, has come to nothing. Efforts are being made to develop interest in other quarters.

Sub-Committee on Materials of Electrical Engineering (Mr. R. D. Mershon, *chairman*). This committee was suspended for a year during the activities of the members on Preparedness work.

Sub-Committee on Safety Valves. Several papers were produced on the subject of safety valves as the result of efforts of this committee. The resignation of Prof. E. F. Miller, the chairman, halts progress for the present, particularly as the immediate grounds have been covered.

Sub-Committee on Worm Gearing (Mr. Fred. A. Halsey, *chairman*). The work of this committee is at a standstill for the present, due to lack of funds to undertake the actual research work required. Work will probably not be taken up again for another year.

Work for 1916. At the meeting held September 15, a plan was put forward to insure a certain amount of work being covered by the various sub-committees. Bibliographies will be prepared on all those subjects requiring reference work, and from these bibliographies a compendium of the subject undertaken will be reported; this work is to be completed during the ensuing year. It is possible experimental work will be undertaken: in the case of the Flow Meters Committee this is at present under way.

The present method of action of the Research Committee is almost entirely by correspondence. Meetings of the main committee and the chairmen of the sub-committees are held three times a year only; all other work being carried on by correspondence between the members of committee and the chairmen of the sub-committees. A monthly progress report is also requested to keep the members of the Standing Committee in touch continually with the work being done by various sub-committees.

R. J. S. PIGOTT, *Chairman*,
RICHARD H. RICE,
R. D. MERSHON,
A. M. GREENE, JR.,
CARL C. THOMAS.

REPORT OF LIBRARY COMMITTEE

During the year ended September 30, 1916, there were added to the library of the Society 579 volumes and 161 pamphlets. The United Engineering Society Library, the joint collection of which the Society's Library is now a part, had on the above date 49,702 volumes and pamphlets.

The duplicate collection of some 12,000 volumes has been listed and sold, and the proceeds, $2,500.00, have been added to the endowment fund of the Library.

The American Society of Civil Engineers having, by a large majority vote of its membership, accepted the invitation to become a Founder Society, the library of this Society will be incorporated in the joint library as soon as proper shelving can be provided.

The attendance during the year was 13,981.

The research work done by the Library Service Bureau has increased greatly in volume. Requests for information have come from 68 localities in 23 foreign countries, and from 239 localities in the United States.

JOHN W. LIEB, *Chairman*.
LEONARD WALDO,
JESSE M. SMITH,
W. M. MCFARLAND,
THE SECRETARY.

REPORT OF HOUSE COMMITTEE

The House Committee has held its regular meetings during the past year, and, most fortunately, a full attendance has been present at each meeting.

At the expiration of the fire insurance policies, which have been taken out for a three-year term, a new rate was made, which increased the insurance premium to some 300 per cent. A special meeting was immediately called and arrangements were made to cover the effects of the Society by special insurance until this most unusual occurrence could be investigated.

It was found that the classification under which the previous policies had been written would no longer be accepted, and after five or six months of constant application a series of reductions was obtained which lowered the new rate materially, but still left it 60 per cent above what the Society had previously paid.

While dealing with this insurance matter it also developed that, owing to the nature of some of the insured property, in the event of loss by fire, an opportunity would be immediately presented for a decided difference of opinion as to the amount of claim which the insurance company would recognize. This being the case, a schedule was prepared separating the purely commercial property from that whose value could not be so classed, and this schedule has been placed in the hands of the insurance broker with a view to having it accepted by the insurance company and filed as a part of the insurance policies covering property on the eleventh floor. The property of the Society on the twelfth and fourteenth floors is of commercial nature, and the property of the Society in the Library is not under the House Committee's jurisdiction.

With the decision of the American Society of Civil Engineers to change its headquarters to the Engineering Societies Building, a problem was presented to the House Committee due to certain changes in the building essential to the carrying of the additional three floors. Four steel columns were necessitated from the foundation to the roof of the original struc-

ture and one of these columns passes directly through the Board Room of the Society in a location most inconvenient to the symmetrical arrangement of the rooms.

A number of plans were prepared, and after careful consideration it was decided to change the arrangement of the partitions and to install a cabinet in such a way that the available floor space would not be diminished to any material extent and the symmetry of the rooms would be maintained.

At the time this change is made the three rooms, including the Secretary's office, will be redecorated with a warmer tint than is now on the walls, and the reception hall will also be redecorated in harmony with these rooms. It had been hoped that the building changes would be completed in season to permit the use of the rooms being redecorated prior to the annual meeting of the Society in December. However, owing to the delays in the structural work, it has been deemed unwise to attempt this, as confusion might result during convention week.

Those who attended the President's Reception last year will recall the crowded conditions of the rooms and the confusion resulting during the early part of the evening. Having this in mind, and also that the membership has increased some 700 during the past year, the House Committee finally decided to hold the President's Reception on the fifth floor of the Engineering Societies Building. This marks quite an innovation, and before reaching this decision careful consideration was given to the sentiment which has existed as to the propriety of not holding this function in the Society's own rooms, but the physical impossibility of properly accommodating a large attendance at this function determined the change.

Steps were immediately taken with a view to rendering the fifth floor more suitable to such an occasion. With the generous coöperation of the Board of Trustees of United Engineering Society, the partitions have been changed between the two large assembly rooms and a hardwood floor laid in the larger of these rooms. With these added facilities thus available and the consequent opportunity to enlarge upon the social features of this occasion, it is hoped that this most important evening of the annual convention will be rendered even more enjoyable than those which have afforded an enthusiastic membership opportunity to meet the incoming president in past years.

Pictures of the following Honorary Members have been added during the year: B. F. Isherwood, Dr. Ing. Oscar von Miller, O. Hallauer, Jos. Hirsch, Henry Léauté, F. Reuleaux and Ambrose Swasey.

WILLIAM N. DICKINSON, *Chairman*,
FREDERICK A. SCHEFFLER,
JAMES W. NELSON,
ORRIE P. CUMMINGS,
MAXWELL M. UPSON.

REPORT OF STANDARDIZATION COMMITTEE

The Committee on Bureau of Engineering Standards was a special one appointed to consider and make recommendations on the unification of the general work of standardization within The American Society of Mechanical Engineers, and to consider and make recommendations also looking toward the coöperation of all engineering societies, national as well as international, on all matters dealing with standards.

The work of that Committee culminated in a report that it made to Council and through Council to the membership. This report was published and then adopted by the membership. With that adoption the Committee's work was done and the Committee was discharged.

In order to make effective the work of the special committee and realizing that the activities involved would be continuous, the present Standing Committee on Standardization was provided for by an amendment to the Constitution.

It has not been considered advisable to bring the various committees on special standards that were appointed before your Standing Committee on Standards under the new rules, but all new committees are being appointed and made up in accordance with the lines laid down.

It is gratifying to know that other engineering societies have also realized the desirability of coöperation in this work of standardization; the American Institute of Electrical Engineers in particular is active, and a mutual consideration by the various societies is now being given to this subject.

HENRY HESS, *Chairman*,
H. L. GANTT,
HENRY G. STOTT,
CARL SCHWARTZ,
WM. F. KIESEL, JR.

COLLEGE REUNIONS DURING ANNUAL MEETING

As has been customary during the past few years, the New York Alumni Associations of various colleges where technical courses are given will hold reunions during the Annual Meeting. The following colleges are among those which have planned reunions for College Reunion night, which this year will be on December 8. Complete details are omitted on account of lack of space, but will be included in the final program.

BROWN UNIVERSITY

The Brown University Alumni will hold an informal banquet at the Brown University Club, 44 West 44th Street, on Friday evening, December 8, at 6.30 p.m. Prof. William H. Kenerson will be toastmaster. All alumni interested in engineering and desiring to attend are requested to communicate with Francis P. Davis, 195 Broadway, New York City.

CORNELL UNIVERSITY

The Mechanical Engineering Alumni of Cornell University will hold an informal dinner at Cornell Club, 65 Park Avenue, New York City, at 6.30 p.m. Further information may be had from William F. Hunt, 115 Broadway, New York.

LEHIGH UNIVERSITY

The Lehigh Club of New York will hold an informal dinner and smoker at the Machinery Club, 50 Church Street, New York, at 6.30 p.m., at which Alvan Macauley, Lehigh '92, President of the Packard Motor Car Company, will be the Guest of Honor. Further information may be had from Mr. deCourcy Browne, Room 2203, Equitable Building, 120 Broadway, New York City.

BROOKLYN POLYTECHNIC INSTITUTE

The Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn will hold a reunion at the Engineering Societies Building, at which Frank Gilbreth, Mem.Am.Soc. M.E., will deliver his lecture on Motion Study for Crippled Soldiers. An informal reception and dance will follow. Further details may be obtained from H. A. Brandt, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. (Main 4314.)

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made to any of the candidates posted by January 10, 1917, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected will be notified about February 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE MEMBER

ADAMS, EARL E., Western Representative,
Metals Production Equipment Co., Springfield, Mass.

BILYEU, WILLIAM F., Manager Feed-Water Heater Dept.,
Warren Webster & Co., Camden, N. J.

BERGLAND, ERIC L., Engineering Dept., Light, Heat & Pwr. Div.,
E. I. du Pont de Nemours & Co., Wilmington, Del.

BRAGG, SUMNER B., Foreman, Nosing French Shells,
Midvale Steel Co., Philadelphia, Pa.

BREEZE, ALFRED, Vice-President,
The Cincinnati Ball Crank Co., Cincinnati, Ohio

CHAPIN, WARREN W., Assistant Structural Engineer,
Carrere & Hastings, New York

COONLEY, HOWARD, President,
Walworth Manufacturing Co., Boston, Mass.

DOW, HERBERT W.,
with Nordberg Manufacturing Co., Milwaukee, Wis.

EISLER, CHARLES, Chief Designer,
Westinghouse Lamp Co., Bloomfield, N. J.

EK, ALMA, Master Mechanic,
Braden Copper Co., Rancagua, Chile, S. A.

EVANS, GEORGE A., Assistant to Mechanical Engineer,
Public Service Electric Co., Newark, N. J.

FISHLEIGH, WALTER T., Associate Professor Automobile Engineering, University of Michigan, Ann Arbor, Mich.

GRATIOT, JAMES T., Manager Machinery Department,
Fairbanks, Morse & Co., Denver, Colo.

GROSSHEIM, M. K., Designing Draftsman,
Harry Bentz Eng. Co., New York

HALL, LOUIS J., President,
Columbian Brass Foundry, Freeport, L. I., N. Y.

KELLEY, AUGUSTUS N., Superintendent,
The Modern Foundry Co., Oakley, Cincinnati, Ohio

LACKNER, RAYMOND A., General Manager,
Neely Nut & Bolt Co., Pittsburgh, Pa.

LEWIS, KENNETH B., Manager Dept. of Wire Drawing Equipment,
Morgan Construction Co., Worcester, Mass.

LIDBURY, FRANK A., Works Manager,
Oldbury Electro Chemical Co., Niagara Falls, N. Y.

McGINNIS, CRAWFORD P., Special Rep.,
Pyle National Co., Chicago, Ill.

McINTIRE, CHARLES V., Assistant Engineer,
Otto Coking Co., Inc., New York

McLEAN, ALVA W.,
with The American Well Works, Aurora, Ill.

MEIER, CHARLES,
with The Cincinnati Planer Co., Oakley, Cincinnati, Ohio

MELNIKOFF, NICHOLAS P., Chief Engineer,
Cabinet of His Majesty the Emperor of Russia, Petrograd, Russia

METZ, ELLWOOD A., Chief Draftsman,
Thurlow Steel Works, Inc., Chester, Pa.

PAIGE, HARRISON N., Motive Power Department,
Mount Lyell Mining & Railway Co., Ltd.,
Queenstown, Tasmania, Australia

ROGERS, CLARENCE M., Civil Engineer,
Daytona, Fla.

RUSSELL, ALBERT B., Works Manager,
Library Bureau, Ilion, N. Y.

SMITH, WILLIAM, Mechanical Engineer,
Henry Disston & Sons, Inc., Tacony, Pa.

TALIAFERRO, ROBERT R.,
with Carrier Air Conditioning Co., Cincinnati, Ohio

TONNE, HERMAN A., Machine Designer,
The Standard Shade Roller Corp., Ogdensburg, N. Y.

UNDERHILL, CHARLES R., Chief Electrical Engineer,
The Acme Wire Co., New Haven, Conn.

WATT, HAROLD W., Engineer, Electric Distribution,
Westchester Lighting Co., Mount Vernon, N. Y.

WILSON, THOMAS, Western Editor "Power,"
Hill Publishing Co., Chicago, Ill.

YOUNG, WILLIAM J., Engineer,
Hydraulic Turbine Corp., Camden, N. Y.

FOR CONSIDERATION AS ASSOCIATE MEMBER OR JUNIOR

BINNS, GEORGE W.,
with Cincinnati Milling Machine Co., Cincinnati, Ohio

COOK, HOWARD B.,
with the Warner Elevator Manufacturing Co., Cincinnati, Ohio

FALLOWS, ERNEST, Mechanical Superintendent,
Jenckes Spinning Co., Pawtucket, R. I.

HARRISON, CLIFFORD E., Inspector,
The American Engineering Co., Philadelphia, Pa.

KUEHN, HUGO R., Mechanical Engineer,
Illinois Steel Co., Joliet, Ill.

LINN, SUE SHING, Draftsman,
The American Locomotive Co., Schenectady, N. Y.

McKAIG, ALVIN W., Chief Engineer,
George F. Shevlin Mfg. Co., Saratoga Springs, N. Y.

MAGDEBURGER, EDWARD C., Designing Engineer,
Busch-Sulzer Bros.—Diesel Engine Co., St. Louis, Mo.

MALONE, JOSH G., Draftsman,
Mirck & Co., Rahway, N. J.

MIDDLETON, NATHAN A., Engineer,
Hornblower & Weeks, Boston, Mass.

MOORE, JAMES W., Engineer,
American Cast Iron Pipe Co., Birmingham, Ala.

NICHOLS, ALLEN E., Designing Engineer,
Bureau of Waste Disposal, City of Chicago, Ill.

OVERSTRUD, MELVIN, Production Engineer,
Minneapolis Steel & Machinery Co., Minneapolis, Minn.

SEAVEY, C. LAWRENCE, Industrial Engineer,
Remington Typewriter Works, Ilion, N. Y.

FOR CONSIDERATION AS JUNIOR

BAKER, PHILIP C., Designing, Engineering Dept.,
Board of Water Commissioners, Detroit, Mich.

BEEKMAN, HENRY M., Engineering Dept., Primary Battery Div.,
Thomas A. Edison, Inc., Bloomfield, N. J.

BILLINGTON, RONALD V., Draftsman,
Great Western Sugar Co., Denver, Colo.

BRAKES, JAMES, JR., Instructor in Mechanical Engineering Lab.,
Syracuse University, Syracuse, N. Y.

COOKE, EUGENE L., Assistant to Engineer of Tests,
New York Edison Co., New York

DILLEY, JESSE R., Mechanical Engineer,
Remington Arms-Union Metallic Cartridge Co., Bridgeport, Conn.

FRANCIS, HARRIS S., Foreman Production Dept.,
Safety Car Heating & Lighting Co., Jersey City, N. J.

GAILLARD, DAVID S., Superintendent, Experimental Plant,
American Cyananid Co., New York

HORNER, BENJAMIN B., Engineer,
Consolidated Water Power & Paper Co., Grand Rapids, Wis.

LANE, ABBOTT A., Inspector of Aeroplanes and Motors,
United States Signal Service at Large, Washington, D. C.

LLOYD, AXTELL A., Inspector,
American Ammunition Co., New York

PENN, MARION, Assistant Div. Superintendent,
Public Service Electric Co., Elizabeth, N. J.

POIRIER, AUSTIN E., Assistant to Millwright,
Works Engineer's Office, Union Metallic Cartridge Co.,
Bridgeport, Conn.

RIDER, DAVID S., Assistant Engineer, Power Plant, Scovill Mfg. Co., Waterbury, Conn.

STEDMAN, HAROLD W., Foreman, Electrical Department, Chase Metal Works, Waterville, Conn.

SUTERMEISTER, FREDERICK, Assistant Mechanical Engineer, Chelsea Fibre Mills, Brooklyn, N. Y.

VINNEDGE, EARLE W., with Worthington Pump & Machinery Co., Cincinnati, Ohio

WARREN, WILLIAM H., Efficiency Engineer, Inspiration Consolidated Copper Co., Miami, Ariz.

WILLIAMS, GEORGE L., Mechanical Engineer, Empire Zinc Co., Hanover, N. M.

APPLICATIONS FOR CHANGE OF GRADING

BAILEY, HAZIL H., Resident Engineer, E. W. Clark & Co., Management Corp., Columbus, Ohio

BAILEY, WILLIAM J., District Manager, United Coal Corp., Philadelphia, Pa.

BORDEN, WILLIAM H., Operator, Pacific Gas & Electric Co., San Francisco, Cal.

BOYD, W. WALLACE, Chief Engineer, Buffalo Scale Co., Buffalo, N. Y.

MACDONALD, JAMES V., Member of Firm, Ranald H. Macdonald & Co., New York

ROSE, FRED W., Consulting Engineer, Rose & Harris, Engineers, Minneapolis, Minn.

SMITH, ROY H., Treasurer, The Falls Rivet Co., Kent, Ohio

WEBER, ERWIN L., Consulting Engineer, Seattle, Wash.

SUMMARY

New Applications	68
Applications for change of grading: Promotion from Junior	8
Total	76

GEOGRAPHICAL LIST

Alabama
Birmingham—Moore, J. W.
Arizona
Miami—Warren, W. H.
California
San Francisco—Borden, W. H. (J.)
Colorado
Denver—Billington, R. V.
Gratiot, J. T.
Connecticut
Bridgeport—Dilley, J. R.
Poirier, A. E.
New Haven—Underhill, C. R.
Waterbury—Rider, D. S.
Waterville—Stedman, H. W.
Delaware
Wilmington—Bergland, E. L.
District of Columbia
Washington—Lane, A. A.
Florida
Daytona—Rogers, C. M.
Illinois
Aurora—McLean, A. W.
Chicago—McGinnis, C. P.
Nichols, A. E.
Wilson, T.
Joliet—Kuehn, H. R.
Massachusetts
Boston—Coonley, H.
Middleton, N. A.
Springfield—Adams, E. E.
Worcester—Lewis, K. B.
Michigan
Ann Arbor—Fishleigh, W. T.
Detroit—Baker, P. C.
Minnesota
Minneapolis—Overstrud, M.
Rose, F. W.
Missouri
St. Louis—Magdeburger, E. C.
New Jersey
Bloomfield—Beekman, H. M.
Eisler, C.
Camden—Bilyeu, W. F.
Elizabeth—Penn, M.
Jersey City—Francis, H. S.
Newark—Evans, G. A.
Rahway—Malone, J. G.
New Mexico
Hanover—Williams G. L.
New York
Brooklyn—Sutermeister, F.
Buffalo—Boyd, W. W. (J.)
Camden—Young, W. J.
Freeport—Hall, L. J.
Ilion—Russell, A. B.
Seavey, C. L.
Mount Vernon—Watt, H. W.
New York—Chapin, W. W.
Cooke, E. L.
Gaillard, D. S.
Grossheim, M. K.
Lloyd, A. A.
McIntyre, C. V.
Macdonald, J. V.
Niagara Falls—Lidbury, F. A.
Ogdensburg—Tonne, H. A.
Saratoga Springs—McKaig, A. W.
Schenectady—Linn, S. S.
Syracuse—Brakes, J., Jr.
Ohio
Cincinnati—Binns, G. W.
Breeze, A.
Cook, H. B.
Kelley, A. N.
Meier, C.
Taliaferro, R. R.
Vinnedge, E. W.
Columbus—Bailey, H. H. (J.)
Kent—Smith, R. H.
Pennsylvania
Chester—Metz, E. A.
Philadelphia—Bailey, H. H. (J.)
Philadelphia—Bragg, S. B.
Harrison, C. E.
Pittsburgh—Lackner, R. A.
Tacony—Smith, W.
Rhode Island
Pawtucket—Fallows, E.
Washington
Seattle—Weber, E. L. (J.)
Wisconsin
Grand Rapids—Horner, B. B.
Milwaukee—Dow, H. W.
Australia
Queenstown—Paige, H. N.
Chile, S. A.
Rancagua—Ek, A.
Russia
Petrograd—Melnikoff, N. P.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

M. R. JONAS has accepted a position with the By-Product Coke Works of the River Furnace Company of Cleveland, O., in the capacity of test engineer.

P. S. STEENSTRUP, formerly associated with the export department of the Hupp Motor Car Company of Detroit, Mich., has become affiliated with the General Motors Export Company of the same city.

ALBERT C. DICKERMAN, formerly affiliated with Warren B. Lewis, consulting engineer of Providence, R. I., is now associated with the engineering department of the Sayles Finishing Plants, Saylesville, R. I.

RALPH M. FERRY has assumed the duties of superintendent of the Northern Aluminum Company, Ltd., Toronto, Ont., Canada. He was formerly associated with the U. S. Aluminum Company, New Kensington, Pa.

H. O. C. ISENBERG, until recently in the employ of the Ferro Machine and Foundry Company, Cleveland, O., has become connected with the Scripps Booth Company of Detroit, Mich., in the capacity of chief engineer.

JOHN S. REPKO, JR., formerly assistant maintenance engineer of the Bosch Magneto Company, Springfield, Mass., has accepted a position with the Guanica Central Sugar Company, Porto Rico, as assistant mechanical engineer.

JOHN A. MCCRARY has accepted a position with the C and R Department of the Navy Yard, Washington, D. C. He was formerly draftsman and assistant to general superintendent of The Mathieson Alkali Works, Saltville, Va.

FRANK J. BRYANT has severed his connection with the Andrew McLean Company, Passaic, N. J., and has assumed the position of New Jersey manager of the Huber Hand Stoker Company, with headquarters in Passaic, N. J.

ALDEN W. BALDWIN, formerly with the engineering department of The Deane Steam Pump Plant, Holyoke, Mass., is now an instructor in mechanical engineering in the Towne Scientific School, University of Pennsylvania, Philadelphia, Pa.

SURREY W. SLATER, formerly assistant superintendent of the holder distribution department of The Brooklyn Union Gas Company, Brooklyn, N. Y., has been appointed engineer of The St. Maurice Pulp and Paper Company, Cap Magdeleine, Que., Canada.

HARRY A. NADLER has assumed the duties of factory superintendent of Central Fortuna, Porto Rico. He was, until lately, associated with the Guanica Centrale Sugar Company, Ensenada, Porto Rico, in the capacity of assistant chief engineer.

C. A. BLACK, who for many years has been superintendent of dredg-

ing in the second district consisting of the northern half of the Panama Canal and Gatun Dam, was on September 1, when all dredging districts were combined, promoted to superintendent of the entire dredging division with headquarters at Paraiso.

ANNOUNCEMENTS

E. GYBBON SPILSBURY has gone to Cuba on professional work and will be absent about three weeks.

JAMES GUTHRIE, until recently in the employ of the Curtiss Aeroplane and Motor Corporation, Buffalo, N. Y., has opened a consulting engineering office in Cleveland, O.

F. H. BALLOU, traveling engineer of the Great Wetsern Sugar Company, Denver, Colo., has been transferred to the Montana district, Billings, Mont., in the capacity of assistant engineer.

SANFORD E. THOMPSON announces the opening of new offices and laboratory in the Federal Street Building, Boston, Mass. These replace both the Newton Highlands and the Milk Street offices.

R. G. CLYNE, for the past seven years with the Western Cartridge Company of East Alton, Ill., as mechanical engineer, has resigned and will go into business for himself in St. Louis, Mo., designing and building special machinery. He has devoted over 26 years to this class of work.

APPOINTMENTS

J. HARLAND BILLINGS is now lecturer, in charge of the machine design department, at the University of Toronto, Toronto, Ont., Canada.

J. R. BOLGIANO has been assigned by the Emerson Company, with whom he is associated, to the efficiency department of the Dayton Malleable Iron Company.

L. H. BLOOD, mechanical superintendent of the Wood and Brooks Company, Buffalo, N. Y., has become associated with the Lodge and Shipley Machine Tool Company, Cincinnati, O.

BENJAMIN E. BOSLER, formerly assistant superintendent of shops of the Cambria Steel Company, Johnstown, Pa., has been appointed superintendent of the mechanical department of the company.

AUTHORS OF PAPERS, ETC.

C. H. BIERBAUM presented a paper on Graphite at the November 29 meeting of The Engineering Society of Buffalo.

DOUGLAS T. HAMILTON delivered an address on Gages and Their Relation to Interchangeable Manufacture before the Springfield Society, Springfield, Vt., on November 14.

B. NAGY presented a paper on Hydrated Lime—Its Use in Concrete and Mortars, at the November 3 meeting of The Detroit Engineering Society.

RUSSELL HUFF will present a paper entitled A Plea for the Four Cylinder Engine, at the December 13 meeting of The Engineering Society of Buffalo.

W. L. R. EMMET presented a paper on Alquist Gearing for Ship Propulsion at the 24th general meeting of The Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17.

FREDERIC G. COBURN presented a paper on The Power Forging of Chain Cables at the November 16 and 17 meeting of The Society of Naval Architects and Marine Engineers.

L. W. HELMREICH, head of the department of electrical engineering of The David Ranken, Jr., School of Mechanical Trades, St. Louis, Mo., gave a talk on the purpose and scope of the school at the November 1 meeting of The Engineers' Club of St. Louis. The meeting which was held at the School, was followed by an inspection of the shops and laboratories.

NECROLOGY

FRANK EDSON SHEDD

Frank Edson Shedd was born in Sharon, New Hampshire, July 18, 1856; attended the Conant High School of East Jaffrey, New Hampshire, and graduated from Dartmouth College in the Class of 1880. After a year of teaching as principal of a High School he was in the service of the United States Coast and Geodetic Survey for a year, his work being on the charting of the coast of Maine.

In 1882 he left the government service to take up civil engineering in Lowell. In 1886 he had charge of the erection of the Washington Mills at Lawrence, Mass., at that time one of the largest mill-construction propositions that had then been undertaken, and now owned by the American Woolen Company. In April, 1887, he became a member of the staff of Lockwood, Greene & Co., who designed the Washington Mills, and two years later was made first assistant to Mr. Stephen Greene, then the sole member of the firm, and has ever since maintained an intimate connection with that organization. On January 1, 1901, upon the incorporation of Lockwood, Greene & Co., Mr. Shedd became a director and the vice-president of the firm, both of which positions he held until his death.

Mr. Shedd was a civil engineer of high standing, had designed many large mills and hydraulic plants in various parts of the United States and Canada and was considered one of the leading authorities in this country on hydraulic developments.

He was a man of varied interests; a member of the American Society of Civil Engineers; the Boston Society of Civil Engineers and The American Society of Mechanical Engineers.

JOHN E. MC INTOSH

John E. McIntosh was born at Cayuga, N. Y., on February 17, 1858, and died on September 17, 1916. He was educated at Cayuga, at the St. John School, Mantius, N. Y., and at Columbia University. He founded the McIntosh & Seymour Co. about 1885 and was president of this concern until his retirement from business a few years ago. His invention of a flywheel governor made possible the beginning of the company. Mr. McIntosh had great ability as a practical mechanic and also as a boat builder, having built several large boats for his own use.

He was a member of the Citizens' League of Auburn, the City Club of New York, City Club of Auburn, Owasco Country Club, Technology Club of Syracuse, Atlantic Deeper Waterways Association, Auburn Chamber of Commerce, and was National Chancellor of the Chamber of Commerce of the United States. He also served one term as Mayor of the City of Auburn. Mr. McIntosh became a member of the Society in 1901.

JOHN VANDERVEER BEEKMAN

John Vanderveer Beekman was born in Peacock, Morris Co., N. J., on February 7, 1842, and received his education in the district schools near his home. For four years he served an apprenticeship at Dunham & Staats Iron Works, at Raritan, N. J. He then went to Brooklyn, where he remained for six years with the South Brooklyn Engine Works. For two years following this he engaged in business for himself, having a general machine shop in Brooklyn which was afterwards organized as the Pioneer Iron Works of which he was manager. Finally he became interested in the Lidgerwood Manufacturing Company, manufacturers of hoisting engines and boilers. He was well known in engineering circles and was the inventor of many devices now in use on hoisting engines. He was a member of the Machinery Club, and also of the Plainfield Country

Club, and the Hydewood and Stamford Golf Clubs. He became a member of the Society in 1889.

Mr. Beekman died at his home in Plainfield, N. J., on September 11, 1916.

EMIL HERTER

Emil Herter was born in New York City on January 16, 1860, and received his education in the public schools of New York. From 1874 to 1880 he served an apprenticeship with Gustav Burger, and from 1881 to 1883 held a position in the drawing room of the Rider Hot Air Engine Company at Walden, N. Y., and with J. H. Wright at Bridgeport, Conn. From 1883 to 1884 he worked in the shop of the Colts Patent Fire Arm Company. His other practical experience included positions as patternmaker and machinist with the Goshen Foundry & Gas Machine Co. at Goshen, N. Y., draftsman with Brown & Hall, New York City, and Adams & Richards, New Brunswick, N. J. He had charge of erecting machinery at the Niles Tool Works, Hamilton, O., and following that worked as draftsman with the E. W. Bliss Company in Brooklyn. From 1890 to 1892 he had charge of machine shop work in the Schenectady branch of the Edison General Electric Company. After this he held the position of chief draftsman with the New Jersey & Pennsylvania Concentrating Works. At the time of his death he was chief mechanical engineer with the Edison Storage Battery Company, working on many of Mr. Edison's most important inventions.

Mr. Herter became a member of the Society in 1894. He died on August 23, 1916.

THEODORE NEWELL ELY

Theodore Newell Ely was born at Watertown, N. Y., on June 23, 1846, and died at his home at Bryn Mawr on October 28, 1916. He received the degree of C. E. at Rensselaer Polytechnic Institute in 1866, and the honorary degree of M. A. from Yale University in 1897, and that of Sc. D. from Hamilton College in 1904.

Mr. Ely's entire business career was spent in the employ of the Pennsylvania Railroad, the engineering department of which he entered in 1868. From 1903 to 1910 he was chief of motive power of the lines east and west of Pittsburgh and Erie, and at the time of his retirement in 1911 was chief of the whole system.

He was also a director of the Pennsylvania Steel and the Cambria Steel Companies, and was a member of the Permanent Commission of the International Railway Congress, a member and president since 1904 of the Eastern Railway Association, and a member of the American Railway Association, the American Society of Civil Engineers, the American Institute of Mining Engineers, the Institute of Civil Engineers of Great Britain, the American Philosophical Society, the American Historical Association, and The Franklin Institute.

Mr. Ely was a fellow of the American Association for the Advancement of Science, vice-president of the American Academy in Rome, and was an honorary member of the American Institute of Architects. He belonged to the Century, University, and Engineers' Clubs of New York, the Philadelphia and Engineers' Club of Philadelphia, and the Metropolitan Club of Washington. He was known for his interest in art and music, and was a director of the Philadelphia Academy of Fine Arts and a trustee of the Drexel Institute and the Philadelphia Commercial Museum. Mr. Ely became a member of the Society in 1880.

SOCIETY MEETINGS

MEETINGS of the Society are now being held regularly at established Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, St. Paul and Minneapolis (Minnesota Section), New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester; also the Providence Engineering Society, which is affiliated with our Society, holds regular meetings. Sections are in prospect at Baltimore, Erie, Kansas City, Meriden and Rochester.

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the Sections and Student Branches are urged to make every effort to get the complete reports of their meetings to the office of the Society as quickly as possible after the meetings are held, and also, where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. Reports of meetings must be received before the 18th of the month in order to appear in the next issue of The Journal.

PROVIDENCE, OCTOBER 25

A meeting of the Providence Engineering Society was held on October 25. This was the first general meeting of the new Society and a large number attended. Forty-one new members were elected and eleven new applications were received. Professor Kennison, Mem.Am.Soc.M.E., of Brown University, gave an instructive talk on Iron—from the Ore to the Finished Article, which was illustrated by moving pictures of the various processes.

ALBERT E. THORNLEY,
Section Secretary.

BUFFALO, OCTOBER 18

The Engineering Society of Buffalo held its first meeting for season 1916-17 on October 18. A dinner in which about 150 members participated, was a feature. After the dinner, Dr. D. S. Jacobus, President of the Society, gave an address emphasizing the importance of coöperation between the national societies and local groups.

Mr. Rice said that there was a tendency today in the profession toward better recognition of the qualifications of the engineer in the administration of municipalities and mentioned particularly the City of Cleveland. He also stated that the professional engineer is taking a leading part in the industrial preparedness question.

S. J. FOLEY,
Corresponding Secretary.

ST. LOUIS, OCTOBER 14

The first meeting of the St. Louis Section for the season 1916-17 was held on October 14; about 40 members were pres-

ent. The speaker of the evening was L. C. Nordmeyer, Mem. Am.Soc.M.E., who had just returned from an eighteen-months' sojourn in China where he was supervising the construction and starting up of a large plant for storing and preparing eggs for export shipment. The recounting of some of his personal experiences as well as his description of Chinese life in various phases was very interesting.

H. R. SETZ,
Section Chairman.

ST. LOUIS, OCTOBER 18

At the October 18 meeting of the St. Louis Section of the Society, a paper was presented by E. R. Fish, Mem.Am.Soc. M.E., on Standardized Boiler Construction. He called attention to the meaning and importance of the Boiler Code recently issued by the Society which is more and more becoming the recognized standard to state authorities and inspection companies.

In the discussion which followed, representatives of inspection companies explained why there had at first been some opposition on their part towards this new code, but stated that they had now adjusted themselves to the new condition.

H. R. SETZ,
Section Chairman.

NEW YORK, NOVEMBER 14

A meeting of the New York Section was held on the evening of November 14 in the auditorium of the Engineering Societies Building. The chairman introduced Baron Shiba, head of the mechanical enegineering department of the Imperial University of Tokyo and past-president of the Japanese Society of Mechanical Engineers, who brought greetings from the engineers of Japan to the Society, and who received the greetings of our members in return. The chairman then introduced Mr. Charles H. Bedell, electrical engineer of the Electric Boat Company, New London, Conn., who delivered an illustrated lecture on submarines. This lecture had been specially arranged as a sequel to the joint excursion of the New York, New Haven, Boston, Worcester and Providence Sections on Saturday, November 11.

The speaker introduced his subject in a very interesting way by comparing the capabilities of the *Nautilus* of Jules Verne with what we are able to do today. With the aid of lantern slides he then reviewed the history of the submarine, following with a complete description of the interior of a modern vessel. He showed numerous pictures of the latest types of submarines, including a number of American boats, some late type English submarines, and the German merchant submarine *Deutschland*, showing photographs of the interior of the latter and comparing it with fighting vessels. He concluded with an illustrated review of submarines in operation, showing vessels awash, partially and wholly submerged and diving, and an exposition of the defensive use of submarines for the protection of our coasts.

The speaker has had over twenty years' experience with submarines, and throughout his lecture he recited many interesting incidents in connection with this, so that his audience of 500 were well entertained during the whole evening.

The meeting was preceded by an informal dinner at Offer's Restaurant, 38th St. and 6th Ave., at which fifty were present.

A. D. BLAKE,
Section Secretary.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

The Student Branch of the Carnegie Institute of Technology held its first meeting on October 18. H. A. Madison, Chairman of the Branch, in his opening address said that a new feature would be instituted in the Branch this year in the form of a "Suggestion Box," into which any member or non-member can drop suggestions as to subjects or speakers. He felt that this would be very valuable and hoped that a large number of students would make use of it.

The speaker of the evening was C. W. Starker of the Educational Department of the Westinghouse Electric and Manufacturing Company. His subject was Electric Drives in Mechanical Engineering, and he gave a very interesting illustrated lecture on Westinghouse motors of all sizes, from the smallest size for dentists' use to motors of 30,000 h.p. The illustrations included applications on the Great Lakes. Mr. Starker also pointed out the advantages from the use of the different types of motors on their special class of work.

J. H. DAVIS,
Branch Corresponding Secretary.

CASE SCHOOL OF APPLIED SCIENCE

Calvin W. Rice, Secretary of the Society, addressed the Student Branch of the Case School of Applied Science at its meeting on October 17 on The Recognition of the Engineering Profession. He told of the organization of the scientific and industrial resources of the nation, urged a higher motive for scientific researches and councils and spoke of the increasing necessity for the engineering profession to assume its proper place in public affairs.

At a meeting of the Branch on November 1 the students were addressed by Professor R. H. Danforth on Fuel Combustion for Gas, for fuel oil, for pulverized coal and for bulk coal. The lecture was illustrated by lantern slides.

A. TREUHAFT.
Branch Corresponding Secretary.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held October 16, at which the following officers for the year were elected: George Law, president; Max Gorton, vice-president, and Edwin Johnson, secretary-treasurer. Professor L. D. Crain was recommended to the Society for Honorary Chairman.

Following the election of officers Professor Crain gave a talk, explaining the object of the Student Branch and the benefits the students will derive from membership in it.

Coy Hoffman gave a paper on the new boiler plant of the Ford Automobile Company, calling particular attention to the great efficiency of floor space, saving in cost of building per boiler horsepower and saving in fuel cost.

EDWIN JOHNSON,
Branch Secretary.

LEHIGH UNIVERSITY

The first meeting of the Student Branch of Lehigh University was held on October 26. A. H. Langenheim, '17, spoke on the subject of The Layout of an Alkali Plant at Niagara Falls. Several diagrams were used by him to make his descriptions clearer. He explained how alkalis and chlorine are manufactured by an electrolytic process in which the raw brine is decomposed by a strong current, thus producing the gas and leaving a dilute solution of the alkali, which is concentrated by evaporation. The operation must be carried on with great care, due to the danger of handling the products.

J. E. Frobisher, '17, read a paper by S. T. Harleman, M.E., '01, superintendent of the Crucible Department of the Bethlehem Steel Company, who could not be present at the meeting. This paper dealt with the early history of the steel in-

dustry and the development of steel making, and included a discussion of the ancient wool steel and finishing with the modern processes, such as crucible, open hearth, Bessemer and the recent electric types. Each of these methods was taken up in turn and their advantages considered.

F. M. PORTER,
Branch Secretary.

PURDUE UNIVERSITY

A joint meeting with the Student Branch of the A.I.E.E. of Purdue University was held on October 24, at which Charles Cottingham gave talks entitled A Trip through the Krupp Gun Works, Manufacture of Paper and The Panama Canal built before your eyes. The slides showing the Krupp Works were very impressive because of the immenseness of the different operations. The point emphasized in the manufacture of paper was that the raw product was practically the same for all grades of paper, the difference in the product being introduced in the methods of manufacture.

G. A. RUESS,
Branch Corresponding Secretary.

UNIVERSITY OF ILLINOIS

The regular meeting of the Student Branch of the University of Illinois was held on October 12. Following a short business meeting, F. E. Evans talked on Manufacturing Methods at the Overland Automobile Factory. His talk dealt principally with the work of the assembling department of the factory and gave a chronological outline of the assembling process. It was supplemented by a fifteen-minute discussion of questions put to him regarding details of work in the Overland factory.

At a meeting of the Branch on October 26, V. S. Day spoke on Power Absorbing Dynamometers. The talk included a history of the absorption brake, classification of the different types of brakes and constructional features of the friction brake, and water and electric brakes. A short theoretical development of the horsepower formula concluded the talk.

V. S. DAY,
Branch Chairman.

WASHINGTON UNIVERSITY

A meeting of the Washington University Student Branch was held on October 25, at which E. H. Tenney, assistant to the chief engineer of the power plant of the Union Electric Light and Power Company, of St. Louis, Mo., gave an illustrated lecture on the construction of the Ashley Street plant of the above company, showing the tunnels, piping and installation of turbines and engines. There were also slides showing the method for reconstructing a part of the plant.

The total output of the plant at the present time is about 56,000 kw., and when additions are made the output will be about 81,000 kw.

WALTER HENRY KURTZ,
Branch Corresponding Secretary.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 18th of the month.

ESTIMATOR, young man, technical graduate with experience in foundry and pattern work and familiar with cast iron and steel, to take charge of estimating department for large foundry. Location Maryland. 397

SALESMEN ON POWER PLANT EQUIPMENT, commission basis. Equipment consists of boilers, engines, forced-draft blowers, pumps and elevators. 402

EXPERIENCED MAN on twist drills, one thoroughly familiar with twist drill making machines and able to assist in designs for new factory; to be placed in charge of department as soon as started. 413

ESTIMATOR, a plant in western New York manufacturing steel plate tanks and receptacles, desires services of estimator for this class of work. In first letter please state age, experience, training, whether single or married, salary expected, present employment. Correspondence confidential. 634

Three or four recent GRADUATE MECHANICAL ENGINEERS required on tests, inspection of materials, writing of specifications, etc. Salary $18 per week. 635

GRADUATE ENGINEER thoroughly familiar with materials of automobile construction, shop practice and costs, desired by large automobile manufacturer. Good opportunity for man capable of reducing costs. State age, experience, references and salary expected. Location New York State. 636

PRODUCTION ENGINEER, preferably young mechanical engineer with good machine-shop experience in costs, efficiency engineering, and factory management, thorough knowledge of modern methods in securing increased output and decreased costs. Salary according to experience and ability. Location Boston, Mass. 640

YOUNG ENGINEER, some experience in modern factory transportation: should be familiar with handling methods, and with use of lift trucks, cranes, conveyors, etc. Location Connecticut. 641

WORKS MANAGER, unusual opportunity for right man, 35-45, must be graduate engineer and have thoroughly demonstrated ability as machine designer and production man. Good organizer and hustler preferably with ability to invest $5,000 at the end of 3 months if satisfactory. 642

MECHANICAL ENGINEER for inspecting various lines of machinery with different manufacturers. Headquarters New York. 643

ENGINEERING EDITOR for established technical monthly published in New York City. Man preferably 25 to 30 years old, either mechanical or electrical engineering graduate with some experience in publishing business. Salary $25 a week and a share in the profits. Must be an enthusiastic writer, energetic, willing to attend conventions, speaking when necessary. Should desire to make publishing his life work, and be ready to start immediately. 644

TECHNICAL GRADUATE having several years successful general engineering experience in industrial plant, to act as assistant to plant engineer; must be keen observer, aggressive, have originality and initiative. State age, experience, references and salary received. Name confidential. Location Detroit. 648

FOUR YOUNG ENGINEERS, about 25 years of age, technical graduates. Two for technical commercial work and two for office side of work. Some mechanical and electrical experience. 651

MECHANICAL, ELECTRICAL and COMMERCIAL ENGINEERING FIRM in New York desires to engage a business-getter to call on prospective clients, attend to publicity work and generally develop business. Man about 30 years of age with technical education and some selling experience desired. Drawing account and expenses will be allowed and liberal percentage on the business developed. Reply fully stating age, experience and qualifications. 655

DRAFTSMAN, on plant layout and machine design. 656

ASSISTANT TO POWER ENGINEER of large industrial plant. Technical graduate. For general power testing and inspection. Must be familiar with testing steam and electrical equipment. Salary $1,000 to $1,200. 660

CHIEF ENGINEER to take charge of power plant in Greater New York; 800-h.p. boilers, engines, etc., and general equipment. Desire references, experience, nationality. Salary $40 to $50 per week. 662

EXPERIENCED PUMP DRAFTSMAN. Salary $22 to $26 a week according to ability. Permanent position. 664

HEATING AND VENTILATING ENGINEER, young technical graduate, with three or four years' experience. Location Ohio. 665

SUPERINTENDENT for an automobile tire factory, who understands compounding, and is experienced in machinery and installation. Location Minnesota. 666

SUPERINTENDENT or MASTER MECHANIC for large industrial plant; competent to handle the mechanical departments of company having 9,000 employees. Location Ohio. 667

MECHANICAL DRAFTSMAN, experienced on general engineering work, preferably including some structural experience. Location South Bethlehem, Pa. 668

YOUNG ENGINEER to go to England; must be competent to undertake all variety of engineering, both in England and countries on the continent. Apply by letter. 675

INSTRUCTORS for school of mechanical trades in Iowa. Salaries $1,000 to $1,200 per year; promotion dependent to large extent upon the commercial work which can be turned out during the year.

(a) Energetic young man with some business ability to take charge of automobile department; must know his subject thoroughly and be able to build up the department educationally and commercially, as the department is doing a large repair business. Competent to teach in automobile lines, including electric cranking, lighting and ignition course, be able to organize material and work in such way that a maximum number of students can be handled with minimum teaching force and expense.

(b) Man to handle foundry and machine shop and possibly forge. 676

PLANNING DEPARTMENT AND TIME STUDY MEN. A well established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special reference to time study the determination of standard tasks and planning and scheduling production. In reply state age, education, experience, present and expected salary. 679

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

ENGINEERING EXECUTIVE or confidential position by man just completing standardization proposition. Practical and theoretical experience. Would consider connecting with new enterprise, development or installation of new project or system, or taking charge of engineering or confidential interests of individual or corporation. Best references of ability, standing, etc. Will go anywhere. L-398

SALES MANAGER, EXECUTIVE or MANUFACTURERS' AGENT. Associate-Member, age 40. Seventeen years experience in boilers, stokers and kindred lines. Has international reputation as master salesman. Diplomatic, forceful and energetic and accustomed to meeting the men "higher up." Desires connection with manufacturers requiring representation in Central and Northwest with headquarters in Chicago. Intimately acquainted with largest corporations and industrial concerns in this section. L-399

JUNIOR MEMBER. Stevens graduate. Varied experience as safety engineer, designer and test engineer on power-plant equipment and assistant to chief engineer on ordnance and munitions. Desires to associate with engineering firm where technical and business knowledge can be used to advantage. Vicinity New York preferred. Salary secondary to opportunity. Available immediately. L-400

WESTERN REPRESENTATIVE. Member, practical machinist, Stevens graduate; engineering business and buying experience. Easterner with residence of ten years in the West. Age 36, married. Now employed by mechanical-engineering contracting concern. Desires change and solicits position as Pacific Coast representative of Eastern manufacturer. Salary and commission basis. Would consider two non-conflicting lines. References. L-401

EXECUTIVE. Desires position in medium-size city in Middle West as manager or assistant manager and superintendent of electric power company or similar position with manufacturing company. Graduate M. E., age 34. Eleven years experience in manufacture, construction, operation and sale of power-plant machinery; thoroughly experienced in managing departments. L-402

STEAM OR DIESEL ENGINES, electrical equipment, air compressors and pumping engines. Member experienced in these lines and at present holding responsible position desires change. L-403

EXECUTIVE ENGINEER. Desires position as works manager, production manager, superintendent inspection or other executive position. Technical education. Fifteen years' experience handling men and production in large plants, conveying machinery, automobile axles, typewriters, ball and roller bearings, wire wheels and artificial leather. Familiar with scientific management. L-404

TECHNICAL GRADUATE. Junior Member. M. E., Class of '15. Age 27, four years' machine shop experience. Desires position with future. Now employed. Location not essential. L-405

M. E. GRADUATE, 1916. Desires position where technical training will be of service and advancement will be commensurate with services rendered. At present employed. L-406

SALES MANAGER, SALESMAN or EXECUTIVE ENGINEER. Technical graduate, thoroughly experienced in shop methods, testing and design of power-plant equipment, and with wide experience and successful record of salesmanship in mechanical lines. New York or Middle West preferred. At present employed. L-407

FACTORY MANAGER. American, age 26. Graduate M. E. Desires to make a change. Has held successfully positions of machinist's apprentice, foreman, inspector, erector, chief draftsman, assistant superintendent, superintendent and factory manager. At present employed. L-408

MECHANICAL ENGINEER. Junior Member. Age 29. Six years experience in machine-shop, mill and power-plant work. Designing, testing and superintending construction. New York City or eastern location preferred. L-409

WORKS MANAGER, SUPERINTENDENT or PLANT MANAGER. M. E. Lehigh University. Several years' experience in management of mechanical department of railroad, coal mining and industrial corporations; extensive experience as plant engineer in mechanical, electrical and construction lines for large manufacturing plants. Good organizer and executive. Qualified to fill position of works manager of industrial plant, manager of coal-mining property, superintendent of motive power of railroad, or plant engineer for large manufacturing or mining company. L-410

MECHANICAL AND COMBUSTION ENGINEER. Junior Member, age 28. Technical graduate and has had three years' experience in steam and combustion engineering. At present employed in 40,000-kva. railway power station. References furnished on request. Location immaterial. L-411

MECHANICAL ENGINEER. Junior Member, age 31, married. Ten years' experience in design, construction and operation of mechanical equipment for power plants, will consider position as sales engineer on salary and commission basis. Location Philadelphia; available January 1. Present salary $135 per month. L-412

MECHANICAL AND MINING ENGINEER. Member, technical graduate, age 47. Many years practical experience in consulting, designing, construction and operation of power plants, copper and lead smelters, crushing and concentrating plants, economical handling of materials, or SALES ENGINEER, handling equipment for above named plants. At present employed, desires to make change as no opportunity for further advancement or responsibility is afforded. Location anywhere if healthy. References. Salary $6,000. L-413

CHIEF ENGINEER, SUPERINTENDENT OF CONSTRUCTION. General master mechanic, maintenance engineer, twenty years' technical training and practical experience as machinist, pipe fitter, machine-shop foreman, draftsman, designer, chief draftsman, superintendent of construction and acting chief engineer on all classes of general plant design, details, construction, rebuilding, improvements and auxiliaries. L-414

MANUFACTURERS' REPRESENTATIVE or AGENT on commission basis for power-plant equipment, machine tools, machinery, or heavy hardware. Graduate mechanical engineer, ten years' experience as New York district manager for well known firm manufacturing mechanical equipment. Would like to hear from firms who desire to increase their sales in the East. Highest references; can prove ability and success in sales engineering with record of increased business. L-415

EXECUTIVE: Graduate mechanical engineer, six years designing, manufacturing and selling experience. At present on the road but wishes to obtain position without travel. Tactful, systematic and conscientious; excellent references. L-416

ASSISTANT TO EXECUTIVE OR CONSULTING ENGINEER: Junior member, Cornell graduate. Age 27. Experienced in fuel and combustion engineering; testing of boilers, engines, stokers, and meters, etc.; cost distribution and operation, maintenance, construction and inspection work in connection with service plants supplying compressed air, refrigeration, steam and hot water heat. L-417

WORKS MANAGER OR EXECUTIVE ENGINEER technical graduate, with varied experience in office, sales and executive work in shop and factory, desires position of representative capacity touching the executive and commercial side of business. Employed. L-418

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

LIBRARY ACCESSIONS

AMERICAN INSTITUTE OF ARCHITECTS. Proceedings of Annual Convention. 47-49. *v.p. 1913-1915.* Gift of Institute.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS. Transactions. vol. IX. *Ames, 1916.* Gift of Society.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Transactions. vol. 37, 1915. *New York, 1916.*

AUTOMOBILE PERFORMANCE FORMULAE, H. K. Thomas. Edited by John Younger. *1916.* Gift of John Younger.

CINCINNATI (OHIO) WATER WORKS DEPARTMENT. Annual Report 1915. *Cincinnati, 1915.* Gift of Water Works Department.

NEW YORK CITY. Board of Water Supply. 10th Annual Report, 1915. *New York, 1915.* Gift of J. Waldo Smith.

PERSONAL REMINISCENCES OF JAMES MAPES DODGE, Charles Piez. 1916. *Chicago, 1916.* Gift of Link Belt Co.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS. Proceedings of 11th Annual Meeting, 1916.

——— Yearbook. August 1916. *Chicago, 1916.* Gift of Wm. S. Boyd.

EXCHANGES

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Report of the Proceedings of the 48th Annual Convention, 1915. *Chicago, 1915.*

CANADIAN SOCIETY OF CIVIL ENGINEERS. Report of Annual Meeting. vol. 28, 1914. *Montreal, 1914.*

TRADE CATALOGUES

BERGER MFG. CO., *Canton, Ohio.* Bulletin no. 12. Metal lumber.

CHICAGO PNEUMATIC TOOL CO., *Chicago-New York.* Bulletin 34-X. Giant gas engines.

DIAMOND POWER SPECIALTY CO., *Detroit, Mich.* Power notes. *September-October 1916.*

FLANNERY BOLT CO., *Pittsburgh, Pa.* Staybolts. *October 1916.*

GLASGOW IRON CO., *Pottstown, Pa.* Catalog, 1916. Iron and steel plates, muck bars and flanged and pressed work.

LESCHEN, A. & SONS ROPE CO., *St. Louis, Mo.* Leschen's Hercules. *October 1916.*

ROEBLING, J. A. SONS CO., *Trenton, N. J.* Wire rope. v. 1, no. 4. *1916.*

STOW MANUFACTURING CO., *Binghamton, N. Y.* Bulletin no. 100. Electric motors.

——— no. 101. Electric tools.

——— no. 102. Flexible shaft.

SWENSON EVAPORATOR CO., *Chicago, Ill.* Evaporators. Single and multiple effects.

TEXAS COMPANY, *Houston, Chicago, New York.* Texaco Star. *October 1916.*

UNITED ENGINEERING & FOUNDRY CO., *Pittsburgh, Pa.* Bulletin M. "United" merchant mills.

WAGNER ELECTRIC MFG. CO., *St. Louis, Mo.* Bulletin 113. A synopsis.

WALWORTH MFG. CO., *Boston, Mass.* Walworth Log. *October 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

AMERICAN PETROLEUM INDUSTRY, R. F. Bacon and W. A. Hamor. vols. 1-2. *New York, 1916.*

APPLIED ELECTRICITY FOR PRACTICAL MEN, A. J. Rowland. *New York, 1916.*

CHEMICAL ENGINEERING CATALOG. 1916 edition. *New York, 1916.* Gift of Chemical Catalog Company.

CHEMICAL STUDY OF ILLINOIS COALS. Coal Mining Investigations. Bulletin no. 3. *Urbana, 1916.*

CITY MANAGERS' ASSOCIATION. Proceedings, 1915. *Niagara Falls, 1915.* Gift of Association.

COAL RESOURCES OF DISTRICT VI—ILLINOIS. Coal Mining Investgations. Bulletin no. 15. *Urbana, 1916.*

COKE INDUSTRY OF NEW SOUTH WALES. New South Wales Geological Survey. Mineral Resources, no. 23. *Sydney, 1916.*

CONCISE TECHNICAL PHYSICS. *New York, 1916.*

CONGRESS AND THE RAILWAYS. Railway Business Association. Bulletin no. 19.

ELECTRICAL ENGINEERING—ADVANCED COURSE, E. J. Berg. *New York, 1916.*

ENGINEERING MANUAL OF THE AMERICAN ELECTRIC RAILWAY ENGINEERING ASSOCIATION. Revised December 1915.

FLOTATION PROCESS, H. A. Megraw. *New York, 1916.*

FRANKLIN INSTITUTE. Year Book 1916. *Philadelphia, 1916.*

GEOLOGY AND MINERAL RESOURCES OF THE YILGARN GOLDFIELD. Western Australia Geological Survey. Bulletin no. 63. *Perth, 1915.*

DIE GESTEINSBILDENEN MINERALIEN, Ernest Weinschenk. *Freiburg, 1901.*

HANDBOOK OF MACHINE SHOP ELECTRICITY, C. E. Clewell. *New York, 1916.*

INTERNATIONAL ENGINEERING CONGRESS, 1915. vol. VIII—Mining Engineering. *San Francisco, 1915.*

JAPAN IMPERIAL GEOLOGICAL SURVEY. Geological Map. Division V. *Tokyo, 1916.*

——— Mineral Map. Division V. *Tokyo, 1916.*

LIST OF INSPECTED ELECTRICAL APPLIANCES, PUBLISHED BY UNDERWRITERS LABORATORIES. April 1916. *Chicago, 1916.*

LIST OF REFERENCES ON VALUATION OF RAILWAYS, AUGUST 1, 1916. Gift of Bureau of Railway Economics.

LOS ANGELES. Department of Public Service. Complete Report on Construction of the Los Angeles Aqueduct. *Los Angeles, 1916.*

MANUAL OF BIBLIOGRAPHY, W. T. Rogers. *London, 1891.* Gift of Arthur Worischek.

MECHANISM OF MEN-OF-WAR, R. C. Oldknow. *London, 1896.*

METHOD FOR MEASURING THE VISCOSITY OF BLAST FURNACE SLAG AT HIGH TEMPERATURES. U. S. Bureau of Mines. Technical paper 157. *Washington, 1916.*

METODO DI RICHERCHE SPERIMENTALI CON MODELLI INTORNO ALLE QUALITA EVOLUTIVE DELLE NAVI, Nino Pecoraro. *Genova, 1916.* Gift of Rivista Marittima.

MINING OPERATIONS IN THE PROVINCE OF QUEBEC, 1915. Report on. *Quebec, 1916.*

NATIONAL FIRE PROTECTION ASSOCIATION. Year Book, August 1916. Gift of National Fire Protection Association.

THE NEW TYRANNY, S. O. Dunn. Address before the Railway Signal Association, September 13, 1916.

PRELIMINARY OIL REPORT ON SOUTHERN ILLINOIS. Extract from Bulletin no. 35, Ill. State Geological Survey. *Urbana, 1916.*

PRINCIPLES OF ALTERNATING CURRENT MACHINERY, R. R. Lawrence, *New York, 1916.*

PUBLIC UTILITIES REPORTS. 1916-D. *Rochester, 1916.*

RAILROADS AND THE PUBLIC, G. E. Ide. *August 1916.* Gift of Bureau of Railway Economics.

RAILWAY FREIGHT RATES, M. H. Robinson. *New Haven.* Gift of Bureau of Railway Economics.

RESCUE AND RECOVERY OPERATIONS IN MINES AFTER FIRES AND EXPLOSIONS, J. W. Paul and H. M. Wolflin. *Washington, 1916.*

SELLING PASSENGER SERVICE. An address by G. D. Dixon, delivered before the American Association of Traveling Passenger Agents, October 2, 1916.

STATISTICS OF THE MINERAL PRODUCTION OF ALABAMA FOR 1913. Alabama Geological Survey. Bulletin no. 15. *University, 1914.*

TRIBUTES TO FREDERICK W. TAYLOR. Gift of F. W. Taylor Co-operators.

UNDERGROUND WASTES IN OIL AND GAS FIELDS AND METHODS OF PREVENTION. U. S. Bureau of Mines. Technical paper 130. *Washington, 1916.*

UNION OF SOUTH AFRICA. General Report of the Miners' Phthisis Prevention Committee. *Pretoria, 1916.*

U. S. BUREAU OF CENSUS. Financial Statistics of States, 1915. *Washington, 1916.*

U. S. CENSUS BUREAU. Mortality Statistics, 1914. *Washington, 1916.*

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AUTOMOBILE ENGINE RATING.
PISTON SPEED VS. R.P.M. AS BASIS OF ENGINE RATING.
AUTOMOBILE ENGINE OUTPUT CURVES, PLOTTING.
LARGE CYLINDERS VS. SMALL CYLINDERS AND OUTPUT.
ESTIMATING MAXIMUM AUTOMOBILE ENGINE POWER.
VACUUM BRAKE FOR AUTOMOBILES.
BALANCED AUTOMATIC CONTROL VALVE FOR VACUUM BRAKES.
OVERHEAD TRAVELING CRANES.
TRACTIVE EFFORT OF OVERHEAD TRAVELERS.
ANGLE OF REPOSE, OVERHEAD TRAVELERS.
CAST IRON, THERMAL REACTIONS.
CAST IRON, EXPANSION-TEMPERATURE CURVES.
CAST IRON, HEGGIE TESTS.
AEROPLANE CONSTRUCTION, MATERIALS USED IN.
AEROPLANE WOODS, PHYSICAL PROPERTIES.
AEROPLANE STEEL TUBING, PHYSICAL PROPERTIES.
STEEL TUBING, THIN WALLED, IN AEROPLANES.
STEEL TUBING, NICKEL VS. LOW-CARBON.
AEROPLANES JOINTS AND WIRE CONNECTIONS, STRENGTH.
MILD-STEEL BARS, EFFECT OF COLD TWISTING.
GATING OF CASTINGS.
COAL (ILLINOIS), SPECIFIC GRAVITY STUDIES.
COAL, BITUMINOUS, CLINKERING OF.
COAL, CHART OF COST ON THE HEAT-VALUE BASIS.
SCHAPHORST CHART FOR DETERMINING COST OF COAL.
HYDRAULIC FLOW FORMULAE.
PISTON RINGS.
HIGH-SPEED STEEL VS. OBTURATOR RINGS.
RINGS IN ALUMINUM PISTONS.
RINGS OF THE BRITISH CHUCK & PISTON RING CO.
METAL BOLTS, LATERAL BENDING RESISTANCE.
LAG SCREWS, LATERAL BENDING RESISTANCE.
VICKERS SURFACE-HARDENING PROCESS.
STRAINER FOR SUDS PUMPS.
SPRINGFIELD MODEL 1903 SERVICE RIFLE.
SPRINGFIELD RIFLE, FIXED BASE.
SPRINGFIELD RIFLE, FINAL BARREL OPERATIONS.
BROWNING RIFLE BARRELS.
MECHANICAL STOKING ON LOCOMOTIVES.
LUBRICATION OF LOCOMOTIVES AND COST OF OPERATION.
SUPERHEATING ON LOCOMOTIVES.
LOCOMOTIVE ARCHES AND BOILER EFFICIENCY.
BOILER OPERATION, STANDARDIZATION OF.
BOILER ROOM, SAVINGS IN.
SAFETY-VALVE AREAS.
MASSACHUSETTS FORMULA FOR SAFETY VALVES.
UNITED STATES GOVERNMENT RULE FOR SAFETY VALVES.
PHILADELPHIA RULE FOR SAFETY VALVES.
A. S. M. E. BOILER CODE RULE FOR SAFETY VALVES.
CANADIAN RULE FOR SAFETY VALVES.
BOILER CORROSION BY MAGNESIUM CHLORIDE.
MAGNESIUM CHLORIDE, DETECTION OF.
AUTOMATIC BALANCED VALVE ON STEAM TURBINES FOR PROTECTING AGAINST LOSS OF VACUUM.
WOMEN, EMPLOYMENT IN GREAT BRITAIN.

In the section Steam Engineering will be found an abstract of an article on standardization of boiler operating conditions. There is nothing striking in this article except the big lesson that it teaches. Subsequent to the appointment of a boiler-room foreman three years ago, the boiler-room efficiency has been increased 40 per cent. Now if somebody patented a new process of steam generation increasing the efficiency of the boilers by 40 per cent, nine plants out of ten would probably have found it worth while to rebuild entirely their machinery, and to consign the existing equipment to the scrap heap. In this case a saving of 40 per cent has been attained practically exclusively by the application of common sense and system, and at the cost of a few indicating and recording instruments.

Of course, the lesson of this article will not apply to every steam plant, because in order to effect a saving of 40 per cent by such methods as were employed in this instance there must have been, in the first place, a loss of 40 per cent, and, fortunately, it cannot be assumed that any large part of our boiler-rooms are operated at such a loss.

There is, however, scarcely any doubt but that in a good many plants the application of some methods like the ones described here might bring rather unexpected results in the way of increase of efficiency and saving of fuel and materials.

This is all the more important, as we are apparently approaching a period of intense competition, both in the home and world markets, when any saving however small becomes worth striving for.

THIS MONTH'S ARTICLES

Methods of practical engine rating are discussed with the view of developing a formula more corresponding to actual conditions than apparently the engine-rating formula of the British Institution of Automobile Engineers. Among other things, the writer shows how widely divergent results may be obtained by plotting curves of automobile engines with different stroke-bore ratios—horsepower against piston speed on one hand, and horsepower against speed in revolutions on the other hand. The comparative efficiency of engines with large and small cylinders and of various types is likewise discussed.

A vacuum brake for automobiles is described with an interesting balanced automatic control valve. In connection with the description of a power plant in Ohio, mention is made of an improvement in underfeed stokers, namely, the incorporation of an automatic self-cleaning clinker attachment.

In the section Engineering Materials data are reported on tests by James S. Macgregor, of Columbia University, of various kinds of timber used in aeroplane construction, as well as on steel tubing. As regards the latter, the writer deems it inadvisable to use very thin-walled tubes with wall thicknesses less than 5 per cent of the outside diameter. As to the material used for tubing, the author does not believe that 3½ per cent nickel steel is much better for tubing than 0.35 per cent carbon steel with, say, 0.6 per cent manganese.

Thermal reactions of cast iron is the subject of a paper pre-

sented by Prof. Thomas Turner, of the University of Birmingham, England, to the recent meeting of the American Foundrymen's Association in Cleveland. The paper is essentially of an experimental nature, and presents interesting data on the points of arrest in cast iron as a function of its impurities, and also as a function of the thickness of the casting.

The effect of cold-twisting on the properties of mild-steel bars has been experimentally investigated at the laboratory of the University of Colorado. This subject is of particular interest because of the extensive use of cold-twisted bars as reinforcing elements in concrete.

A brief abstract discusses the influence of gating on castings.

An abstract of an investigation of the specific-gravity relations of Illinois coal will be found in the section Fuels and Firing. In the section Munitions attention is called to the continuation of the description of the manufacture of the Springfield Model 1903 Service Rifle, from *The American Machinist*.

The factors influencing the results of laboratory fusion of ash are investigated by F. C. Hubley, who recommends incorporation in specifications for a standard test, of a reference to the maximum amount of carbon to be allowed to remain in the sample after incineration.

New hydraulic formulae are reported from a review of a book recently published in England. While the abstract is necessarily brief, particular attention is called to the book itself.

The piston-ring design with particular reference to small gasoline-engine sizes (aero and automobile engines) is discussed in an article abstracted from a British publication. The writer considers it inadvisable to arbitrarily proportion the gap as one-tenth or one-twelfth the diameter of the ring, and states that the gap should be calculated on the basis of stress in the metal, which depends as much on thickness as on diameter. Among other things he cites a case when a reduction of the pressure exerted by the rings increased the speed of a car five miles per hour. The best is to adopt rings of minimum pressure compatible with gas-tightness, and many rings in use today are stronger than they need be.

Data on the lateral bending resistance of metal bolts and lag screws are reported from tests recently made at the Rose Polytechnic Institute by Prof. H. A. Thomas. In the section Machine Shop is described a strainer for suds pumps for use in supplying coolant to machine tools.

In the same section are present data on the Vickers surface-hardening process, especially suitable for dealing with parts of which it is desired to surface-harden only a small portion.

G. H. Boot shows that the accepted theoretical formula as generally used to calculate the pull required to traverse the load with hand-operated overhead traveling cranes is not correct. Among other things, experiments have been made to determine the angle of repose, and the data are presented in the form of a table covering 2½ in., 5-in. and 10-in. diameter rollers.

The subjects of mechanical stoking, lubrication of locomotives, superheating, and the use of brick arches, are discussed in abstracts of committee reports presented at a recent meeting of the Traveling Engineers' Association in Chicago. All through these reports and the other papers presented at the meeting, prominently, like a red thread in a white cloth, passes the dominant idea of the necessity of devising means for coping with the increased weights of trains and increased amount of steam necessary to pull them in on time.

In the section Steam Engineering attention is called to the article on boiler corrosion by magnesium chloride, abstracted from *The Railway Engineer*. Among other things, this article gives simple means for detecting the presence of magnesium chloride.

J. E. Terman, in one of his popular articles running under the general title of Visits of Inspector Brown, discusses and compares the various formulae for safety-valve areas.

Statistical data on the employment of women in Great Britain are given in an abstract from a British publication. Among other things, it presents data on the efficiency of women and the amount of work which they can handle. It is significant in this connection that competent authorities stated their conviction that what women lacked in quantity of work they made up in quality. The same authorities expressed their surprise at the amount of work women could get through if they had sufficient wages to feed and clothe themselves properly. So far the employment of women is confined to work of a repetitive kind, but from what women did on such work it appears likely that under different conditions they might be able to do much more responsible work.

Attention is called to the bibliographical notes on conveying coal through pipes, at the end of the Selected Articles section.

Aeronautics

See ENGINEERING MATERIALS

Automobiles

PRACTICAL ENGINE RATING, Edward G. Ingram

Discussion of previous attempts at developing a rating formula and of various considerations bearing on this subject. The writer considers the formula of the British Institution of Automobile Engineers for automobile-engine rating erroneous because this formula takes piston speed as a basis of rating.

The British formula necessitates the determination of the piston speed in feet per minute at maximum output, instead of the r.p.m. Where the piston speed is already known, the formula may be used, but it is practically useless where the piston speed is unknown and must be determined for engines of various displacements and stroke-bore ratios. In its attempt to find the piston speed at maximum power of engines of different stroke-bore ratios, the British Committee represented it by the equation $s = 600(r + 1)$ ft. per min. This formula, however, gives excessively different speeds of revolution to engines having the same stroke-bore ratio but different displacements. Thus, assuming equal efficiency of engines of the same displacement, maximum power should be reached at the same number of r.p.m., no matter what the stroke-bore ratio, yet the piston speed given by the formula will give different speeds of revolution with engines of different stroke-bore ratios.

Further, the British Committee decided that the mean effective pressure would vary with the size of the cylinder, but it has been shown since that the average m.e.p. is more nearly the same for cylinders of all sizes. Actually, if the average number of r.p.m. had been considered instead of the piston speed, and if the average m.e.p. had been determined with relation to piston displacement and not to the bore, the Committee would have obtained a much more satisfactory formula than the one arrived at, which was: brake horsepower $= 0.45 \times (b - 1.18)(1 + b)$.

It is much better to plot the horsepower against r.p.m., instead of against piston speed in feet per minute. For ex-

ample, in Fig. 1A are shown imaginary curves of two engines of the same displacement but with different stroke-bore ratios, in which power is plotted against piston speed. The engines are assumed to be of the same general construction, so that the power developed will be essentially the same at any given number of r.p.m. up to the maximum. But at any point where both engines are developing the same amount of power the piston speeds will be different, so that the curves will never coincide. If, however, the curves are plotted against r.p.m., one curve will represent both engines, as shown in Fig. B. If these two engines were placed in identical cars, the same gear ratio would be used for both, and the cars would make the same number of miles per hour when the engines were developing the same power. The piston speed, however, would

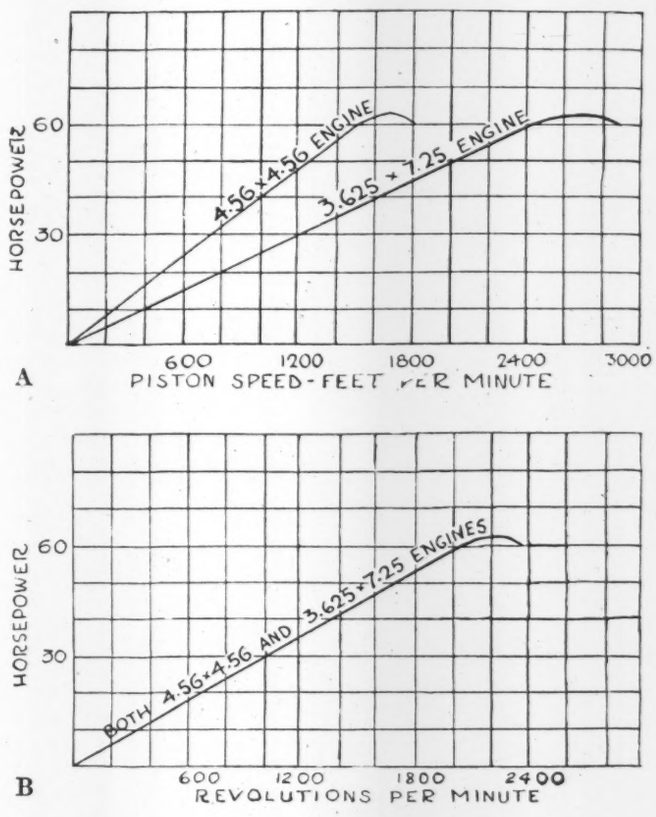


FIG. 1 A, IMAGINARY POWER CURVES PLOTTED AGAINST PISTON SPEED

B, CURVES OF ENGINES IN FIG. A PLOTTED AGAINST R.P.M.

bear no direct relation to the engine output or to the car speed, but would depend upon the stroke-bore ratio. On the other hand, comparing engines on the basis of horsepower per cubic inch of displacement is really the same as considering each to be of the same total displacement, no matter what is the real displacement.

From this the author proceeds to the comparison of different engines, and finds a wide variation in the power developed per cubic inch of displacement by various makes of engines.

He finds also that the tendency is for engines with large cylinders to be less efficient than those with small cylinders, this tendency being more marked in the case of cylinders of over 74 cu. in. displacement. But while engines with large cylinders are less efficient at high speeds of revolution, there appears to be a tendency for them to be more efficient at low speeds, which may be due to the better thermal efficiency, though just why this should be more apparent at low speeds is not altogether clear.

Further, there is apparently a tendency for the small-cylinder engine to develop maximum power at a very high speed of revolution, which seems consistent, since the small cylinder is better off with regard to volumetric efficiency. A characteristic of the Knight stock-car engines is high power efficiency at low revolution speed, even where the cylinders are small, and, besides, maximum power is reached at rather low speed compared to the poppet-valve engines. This may be due partly to higher thermal efficiency and partly to better volumetric efficiency within the engine's speed range. Some engines have been developed so as to give an abnormally high power. In this case the curve is very high at high speeds of revolution and quite low at low speeds, which probably indicates that the valve timing is such as to favor high maximum revolutions at the expense of a slight comparative inefficiency at low speeds.

A fair idea of the maximum power developed by the average touring-car engine of today can be obtained by multiplying

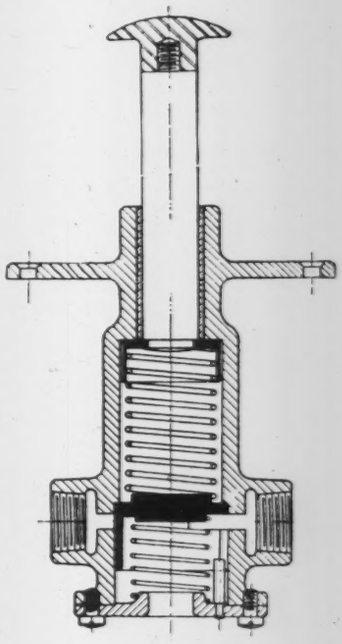


FIG. 2 SECTION OF BALANCED AUTOMATIC CONTROL VALVE

the total piston displacement by 0.17. While many efficient small-cylinder engines will give much greater power than this, and while very-large-cylinder engines or engines of inefficient construction may fall below this output, the rule will give more satisfactory results than those obtained from the rating formula now in general use. (*The Automobile*, vol. 35, no. 17, p. 700, October 26, 1916, 4 pp., 4 figs. *gp.*)

VACUUM BRAKE FOR AUTOMOBILES

Description of an air brake for automobiles, recently placed on the market by the Prest-O-Lite Co. of Indianapolis, Ind.

This brake utilizes the suction prevailing in the intake manifold, the difference between manifold pressure and atmospheric pressure being intensified by the use of a large piston. It is stated that a pressure of about 10 lb. per sq. in. is available, as a rule, and this is used on a piston of 7 in.

diameter with an available stroke of 4 in. A system of levers reduces the travel and multiplies the force correspondingly, so that a powerful pull on the brake-operating rod is obtained. A little valve is placed in the pipe line connecting the intake manifold with the brake piston, and this valve can be operated either by foot or by hand. To give different amounts of pull on the brake rod, the valve is opened by pressing down on a spring, which in turn presses on the valve. The lower side of the valve is exposed to atmospheric pressure continuously, and the upper side of the valve is exposed to the pressure existing within the brake cylinder. Thus, when the valve-operating lever is moved, it presses on the spring and opens the valve. Instantly the pressure back of the valve drops, and the atmospheric pressure on the other side of the valve forces it up against the spring, so cutting off the suction. In this way the depression of the brake cylinder is made proportional to the amount of movement given to the valve operating lever or pedal. Directly the operating lever is released, the valve is lifted right back, and this admits atmospheric pressure to the cylinder, thus releasing the brake instantly. Fig. 2 shows a section of the balanced automatic

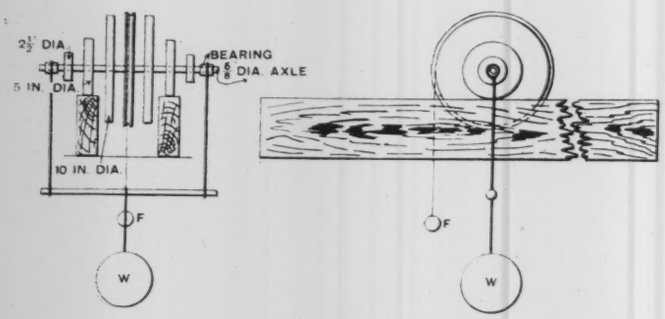


FIG. 3 EXPERIMENTAL APPARATUS FOR TESTING OVERHEAD TRAVELERS

control valve. It is stated that practically the only wearing portions of the whole outfit are the cup leathers.

The author states that the device has been fitted to several cars. (*The Automobile*, vol. 35, no. 13, p. 774, November 2, 1916, 2 pp., 3 figs. *d.*)

Cranes

TRACTIVE EFFORT OF OVERHEAD TRAVELERS, G. H. Boot

The author attempts to show that the accepted theoretical formula as generally used to calculate the pull required to traverse the load with hand-operated overhead traveling cranes, runners, or like appliances, is not correct.

In calculating the pull required to travel the load with all hand-operated gears, the effort required must always be kept within predetermined limits. The pull must be so proportioned that a continuous movement may be obtained, that is, the hand chain must be pulled with a hand-over-hand motion; otherwise the crane will be moved in a series of jerks, and the static friction will have to be overcome at each pull of the hand chain, entailing a considerable amount of additional exertion.

The chief point to be noted in the case of hand-operated appliances is that the static friction, or the tractive effort to move the load from rest, is considerably more than that required after the load has attained a certain speed. The next point, and the one particularly in question, is as to the influence of the diameter of the traveling wheels on the resulting pull. The usual formula for tractive effort is

$$F = \frac{W}{R}(\mu r + f)$$

where F = the tractive effort, W = total load, R = radius of wheel, μ = coefficient of journal friction, f = coefficient of rolling friction, and r = radius of axle.

This expression assumes that the tractive effort is inversely proportional to the diameter of the wheel, other conditions being the same, but from actual tests on railway cars it was found that with wheels 34 in. and 43 in. in diameter the static tractive effort with a load of 32 tons was 22.46 lb. and 20.54 lb. per ton, respectively, while from the above formula it should be as 34:43, that is, for the 43-in. wheel, 17.7 lb. instead of 20.54 lb., which makes a difference of 15 per cent. If a hand wheel be introduced similar to that used on hand cranes, the expression becomes such as to show that where the radius of the hand wheel is constant, the pull required to travel the load is the same for any diameter of wheel, which does not agree with the experimental data given above. Further, from tests on actual cranes it appears that the pull required is not the same for any diameter of wheel.

The author made a series of tests which confirm these facts. The experimental apparatus used is diagrammatically shown in Fig. 3, the rollers being of wood upon wooden rails.

A further experiment to determine the angle of repose, that is, the combined angle of journal and rolling friction for the 2½-in., 5-in., and 10-in. diameter rollers was carried out by raising one end of the rails until the load rolled slowly down the incline, being started by a slight vibration of the apparatus. The combined friction angles were found to be the same for each load of 20, 30, and 40 lb., respectively, on the same size wheel, but the angles for each size wheel differ, as shown in Table 1.

TABLE 1, DATA OF ANGLE-OF-REPOSE TESTS

Diameter of roller, in.	10	5	2½
Length of rail, in.	45	45	45
Rise, in.	0.75	1.22	2.14
Angle ϕ	1°	1°35	2°45
Tan $\phi = \frac{\text{Rise}}{\text{Length}}$	0.0165	0.0272	0.0475

The experiments indicated that in this particular case f is not constant, but varies approximately as the square root of the diameter of the roller, $2R$, so that $f_1\sqrt{2R} = f$.

The formula then becomes

$$F = \frac{W}{D}(\mu r + f_1\sqrt{2R})$$

where D = radius of hand wheel.

The original article contains the curves plotted from results with the experimental apparatus. (*Machinery* [London], vol. 8, no. 211, p. 869, October 12, 1916, 2 pp., 2 figs. *et A.*)

Engineering Materials

THERMAL REACTIONS OF CAST IRON, Prof. Thomas Turner

The writer, who is professor of metallurgy in the University of Birmingham, England, explains the various phenomena of expansion and contraction of cast iron at different stages of cooling, based on previous work of W. J. Keep, of Detroit, and on tests made by the writer himself, with the assistance of Dr. O. F. Hudson.

Among the facts ascertained in these experiments were the following:

1 That most metals and a number of alloys give a regular contraction in the cast bar.

2 That with white cast iron, free from phosphorus, there is only one small expansion, and one temperature arrest, which occurs at about 670 deg. cent.

3 That with gray cast iron, free from phosphorus, there are two well-marked expansions, and two distinct temperature arrests, which occur at about 1,135 and 695 deg. cent., respectively.

4 That with increase of silicon these arrest points occur at higher temperatures and nearer together. In other words, though both are raised, the lower, or pearlite point, is raised more than the upper, or iron carbide eutectic point.

5 That the addition of a small quantity of manganese, together with silicon, diminishes the rise in the pearlite point and leads to a more complete decomposition of the pearlite

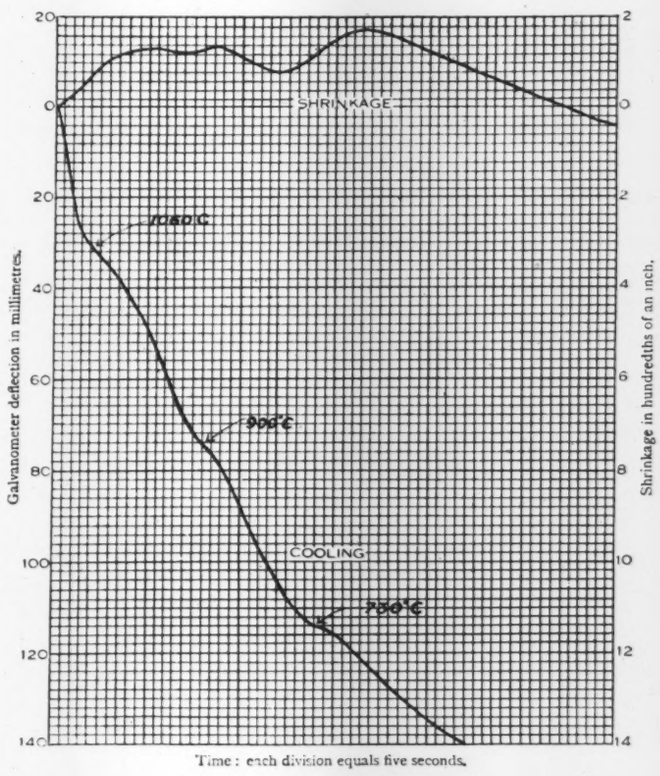


FIG. 4 EXPANSION-TEMPERATURE CURVE FOR GRAY PHOSPHORIC IRON

carbide; in other words, to the production of fine-grained graphite from the combined carbon.

6 That in gray irons containing phosphorus there is an additional, or third, arrest, which occurs at a temperature between those given, or at about 900 deg. cent. A typical expansion curve and the corresponding temperature curve for gray phosphoric iron are given in Fig. 4.

The most important of the conclusions which were derived from these experiments have since been confirmed by other investigations. More recently, Mr. Heggie of Birmingham has conducted a number of tests with the object of ascertaining whether, in actual practice, with varying thicknesses of castings, the expansions follow in the same order as in the earlier experiments of the writer. The tests were made with a rectangular casting of special pattern. It was cast in sand in the ordinary way, but arrangements were made for recording the changes of length of the two sides during cooling (in this casting one side was much thicker than the other). It was found that the expansions in the thin bar were similar to those in the thick bar, and occurred in the same order, but since the thin bar cooled more rapidly, its second expansion occurred while the thick bar was contracting after its first expansion. Hence, while one side of the frame was expanding, the other was contracting, and internal strains were set up in the casting. Positive and negative effects followed, until at length the thin side was uniformly contracting after its third expansion, while the thick side was markedly expanding at about 700 deg. As the metal is quite solid at such temperature, the importance of the strains which are thus set up is readily appreciated. (*The Iron Trade Review*, vol. 59, no. 16, p. 782, October 19, 1916, 3 pp., 2 figs. Paper read at the Cleveland meeting of the American Foundrymen's Association. *te.*)

INVESTIGATIONS CONDUCTED ON MATERIALS USED IN AEROPLANE CONSTRUCTION, James S. Macgregor

Paper read before the Aeronautical Society of America on September 26, 1916. The author is in charge of the testing laboratory at Columbia University.

Table 2 gives results obtained from tests upon several species of wood, and records, in addition to the flexural and compressive resistances, the moduli of elasticity, number of rings per inch, and moisture content.

The author believes that the curing of timber and curing methods should be decided upon subsequent to an examination of the anatomical structure of the timber to be cured. The rapidity with which it can be kiln-dried, the permissible drying temperature, and the permissible rapidity of variation in temperature, are all dependent upon structure.

TABLE 2. PHYSICAL PROPERTIES OF WOODS USED IN AEROPLANE CONSTRUCTION

Material.	Rings per in., over.	Rings per in., under.	Per ct. moisture, cu. ft.	Wt. per lb.	Modulus of rupture.	Compressive strength, lb. per sq. in.	Modulus of elas. (flexure).
Virginia spruce	12		15	21	7,460	4,720	1,289,000
Cedar white	15	25	5-7	25	16,010	9,050	1,920,000
Alaska spruce	16	..	..	..	11,200	7,510	1,512,000
Sitka spruce	10	25	5-13	28	11,000	6,610	1,538,000
Tamarack	..	..	8	29	....	6,649	.....

TABLE 3. DATA OF TESTS ON STEEL TUBING

3½ Per Cent. Nickel Steel

			Torsion tests.		
Specimen No.	Tube diameter.	Wall thickness.	Fiber stress at E. L.	Fiber stress maximum.	Modulus.
1	1.180	.022	....	38,820	9,900,000
2	1.180	.040	39,200	52,920	11,600,000
3	1.182	.061	41,000	61,210	11,700,000
4	1.184	.076	49,700	74,000	11,000,000
5a	1.185	.096	43,500	75,620	11,900,000

	Flexure tests.		Tension tests.	
Specimen No.	Fiber stress at E. L.	Fiber stress maximum.	Yield point.	Ultimate resistance.
1	45,100	68,400	57,540	83,285
2	69,000	127,100	68,470	102,800
3	85,790	127,920	80,570	100,400
4	78,380	136,000	76,510	116,580
5a	94,300	139,400	75,700	117,220

As regards various kinds of timber, Sitka spruce has comparatively high compressive and transverse resistance, and also a high modulus of elasticity. Specifications covering its purchase should always include limitations as to the number of rings of growth per inch, as very coarse material carries very heavy medullary rays, is subject to checking, and is not as strong as the material having a larger number of rings.

Another material which is rapidly finding its way into use in aeroplane construction is steel tubing. There has been a tendency to use tubing of extremely small wall thickness, and apparently it has been assumed that the greater the radius of gyration of section the greater would be the resistance to stress, regardless of wall thickness. Table 2 shows the results of a number of tests in which the outside diameter of the tube was kept constant, and the wall thickness, starting with approximately 0.02 in., was increased by increments of 0.02 in. up to 0.10 in. It was found that the fiber stresses developed by the tubing increased with increase of wall thickness. A wall thickness of about 5 per cent of the outside diameter develops the full strength of the material of which the tubes are composed.

The use of very-thin-walled tubes with wall thicknesses less than 5 per cent of the outside diameter is objectionable, because it disposes the material in a manner which does not permit of the development of the full fiber stress, because the chances of local deformation are very great in such cases, and finally because light-walled tubes might fail with particular ease if rusted.

As to the material used for tubing, the author does not believe that 3½ per cent nickel steel makes the tubing much better than a 0.35 per cent carbon steel with, say, 0.6 manganese.

Tension tests upon tubing of this latter analysis have shown them to have a high yield point, comparatively high ultimate resistance, and a high percentage of elongation.

In connection with the question of heat treatment of tubes after drawing, the writer describes the process developed by Snead & Co., of Jersey City. Another investigation was made upon steel wire and wire connections for tie rods, both unsoldered and soldered joints of various lengths having been tested. The results are reported in the form of a table. (*Aero World,* vol. 1, no. 3, p. 46, October, 1916, 5 pp., 8 figs. *eA.*)

THE EFFECT OF COLD-TWISTING ON THE PROPERTIES OF MILD-STEEL BARS, P. B. Whitney and G. K. Dohner

Cold-twisted bars are extensively used for concrete reinforcement, but have been sometimes found objectionable because of their brittleness. The authors have carried out, at the laboratory of the University of Colorado, a series of tests, the object of which was to determine the effect of twisting upon the properties of steel.

The material used had the following analysis: Carbon, 0.22 per cent; sulphur, 0.039 per cent; manganese, 0.34 per cent; and phosphorus, 0.032 per cent. The bars tested were ⅜-in., ½-in. and ⅝-in. plain square bars. They were 30 ft. in length and were cut so that the whole series of tests could be performed on specimens cut from a single bar, thus assuring uniformity of composition and treatment. The specimens were 16 in., 20 in., and 18 in. long. Half of the specimens were tested unannealed and half annealed. The following results were obtained:

1 *The Effect of Twisting Upon the Elastic Limit.*—The elastic limit was determined from Fig. 5A, it being taken as the first perceptible point of bending in the curve. The results (given in a table in the original article) show that the elastic limit is increased by amounts varying from 10.5 per cent for ⅜-in. bars with one twist in 12 *t* (*t* = size of bar) to 80.45 per cent for ⅝-in. bars with three and one-quarter twists in 12 *t*.

2 *The Effect of Twisting Upon the Yield Point.*—There was no perceptible yield point in any of the twisted bars, although in the plain bars it was very pronounced.

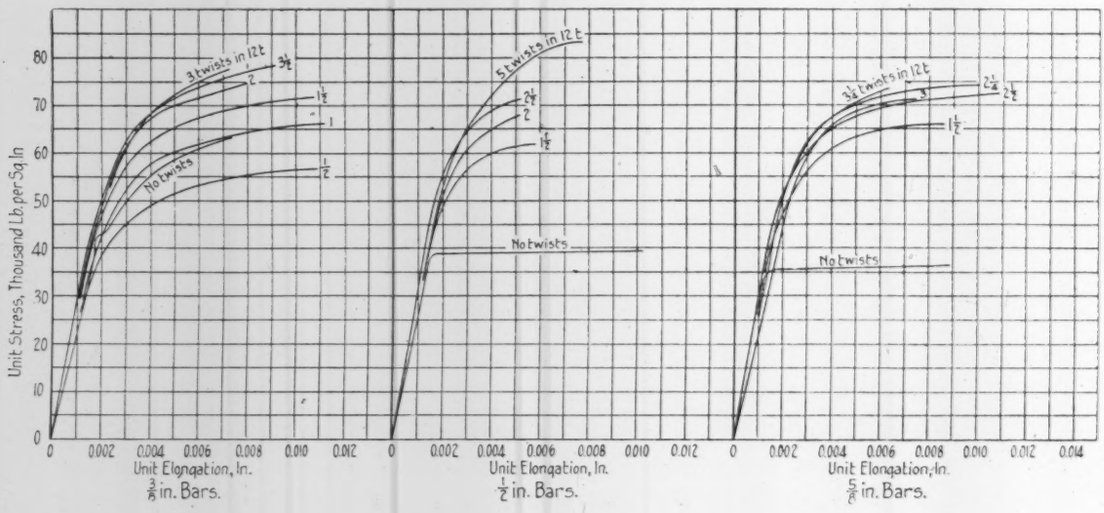

Unit Stress, Thousand Lb. per Sq. In
Unit Elongation, In.
⅜ in. Bars.
½ in. Bars.
⅝ in. Bars.
No twists
3 twists in 12 t
5 twists in 12 t
3½ twists in 12 t

FIG. 5A PARTIAL STRESS DEFORMATION CURVES

3 *The Effect of Twisting Upon the Ultimate Strength.*—The ultimate strength was increased by amounts varying from 2.27 per cent for ⅜-in. bars with one twist in 12 *t*, to 37.86 per cent for one ½-in. bar with three and one-half twists in 12 *t*, as shown in Fig. B.

4 *The Effect of Twisting Upon the Ductility.*—Ductility is indicated by the per cent ultimate elongation and the per cent reduction in area. The per cent elongation for ⅜-in. bars was reduced from 25.37 per cent for plain bars to 3.25 per cent for bars with four twists in 12 *t*. For ½-in. bars the reduction was from 28.7 per cent for plain bars to 0.87 per cent for bars with four and one-half twists in 12 *t*. For ⅝-in. bars the reduction was from 28.5 per cent for plain bars to 3.75 per cent for bars with three and one-quarter turns in 12 *t*.

The per cent reduction in area was reduced from 56.0 per cent for plain bars to 3.7 per cent for bars with three and one-quarter turns in 12 *t* for ⅝-in. bars.

It was found that as soon as a permanent set has been created by torsion there is a noticeable increase in the ultimate tensile strength and elastic limit, but a limit is reached in the number of turns, beyond which the tensile strength is reduced by further twisting. The twisting greatly reduces the ductility. The work required to rupture a twisted bar is much less than that for a plain bar, and decreases very rapidly as the

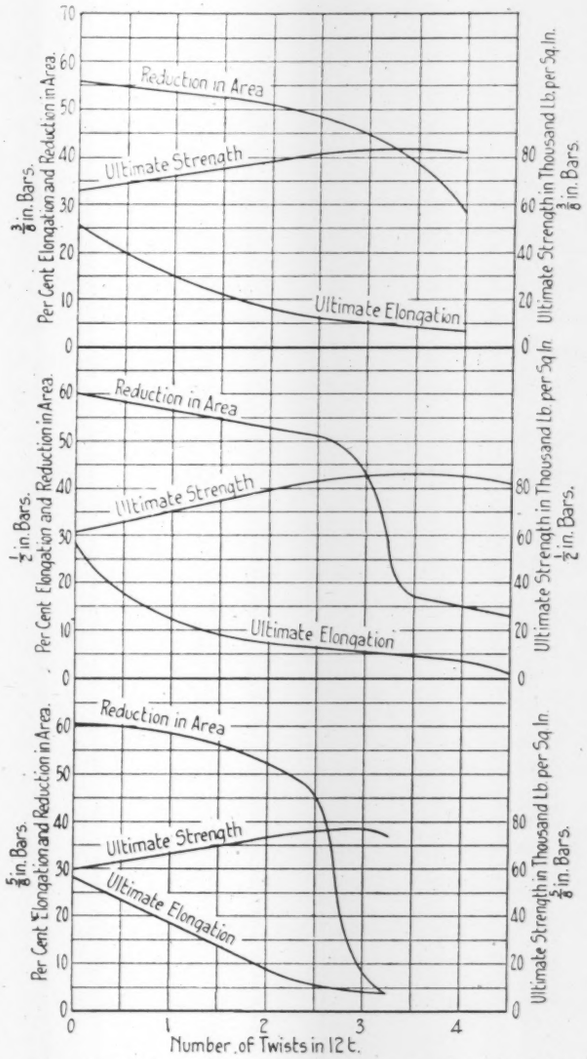

Reduction in Area
Ultimate Strength
Ultimate Elongation
Per Cent Elongation and Reduction in Area.
Ultimate Strength in Thousand Lb per Sq In.
3/8 in. Bars.
1/2 in. Bars.
5/8 in. Bars.
Number of Twists in 12 in.

FIG. 5B CURVES FOR ULTIMATE STRENGTH, ULTIMATE ELONGATION, AND REDUCTION IN AREA

number of turns increases. These results depend upon the size of the bar. (*Journal of Engineering, University of Colorado*, vol. 12, no. 2, p. 48, February, 1916, 8 pp., 3 figs. *e.*)

Foundry

INFLUENCE OF GATING ON CASTINGS, B. D. Fuller, A. M. Fulton, W. J. Gilmore, and R. R. Clarke

Symposium of four papers read at the Convention of the American Foundrymen's Association at Cleveland, Ohio.

There is an intimate relation between the location of the gate and the shrinkage problem. When castings are properly gated and are provided with suitable heads, there is very little trouble from shrinkage, and it is possible virtually to eliminate the use of chills in malleable practice. The correct gating of any casting is just as important as a proper mixture of metal. In designing any gate, two points should be considered, first, can the casting be fed from the proposed gate, excluding slag and preventing misruns, and, second, can the heavy portion be fed by a riser located at the top of the casting. Proper gating is specially important in the production of non-ferrous-metal castings, on account of the difficulties resulting from oxidation of the metal and the comparatively low temperature at which the metal freezes. (cp. *Canadian Foundryman*, vol. 7, no. 10, p. 147, October, 1916. *p.*)

Fuels and Firing

SPECIFIC-GRAVITY STUDIES OF ILLINOIS COAL, Merle L. Nebel

Report of an investigation carried out at the Engineering Experiment Station of the University of Illinois, with an object to determine first the effect of moisture upon the specific gravity of coal, and second, the methods of determining this specific gravity.

As regards terminology, the present investigation follows the practice of the United States Bureau of Mines in distinguishing between the apparent and the true, or real, specific gravity of coal, the apparent specific gravity being the specific gravity of the coal including the moisture or air contained in its pores, while the true, or real, specific gravity is the specific gravity of the actual coal substance corrected for air and moisture content.

For purposes of comparison of the thermal quality of various coals of the Illinois type, the writer uses the "unit coal" basis developed by Parr. Parr, in a previous investigation published by the Illinois State Geological Survey, has shown that if the effects of all the impurities, such as ash, sulphur, and moisture, have been taken into account, the unit B.t.u. is remarkably constant for the coal from a given bed over a considerable area.

A further distinction is made between the fresh specific gravity and the true specific gravity, the former designating the value of the apparent specific gravity of the coal in its fresh condition, that is, the condition in which it exists in the ground.

The writer shows that the hindered settling ratio (for a discussion of the hindered settling ratio, see Bulletin No. 69, University of Illinois Engineering Experiment Station, paper on Coal Washing in Illinois, by F. C. Lincoln) for air-dried coal is just twice that for the same coal when fresh, and, theoretically, the coal when air-dried can be washed with a range of sizes twice as great as when fresh, or with a much cleaner separation for the same range of sizes. From this point of view, the writer advises not to wash fresh coal, or, in other words, not to wash coal at the mine, and not to feed wet coal to jigs or other washing machines.

Practical Uses of the Specific Gravity of Coal. There are several practical uses to which a knowledge of the specific gravity of coal may be applied, chief among which are the following:

1 The calculation of the tonnage of coal in the ground over a given area.

2 The calculation of the tonnage of quantities of broken coal, such as the coal stored in large bins or in stock piles.

3 The comparison of coals by the rapid estimation of the ash and moisture content.

4 The determination of the adaptability of coal to the removal of its impurities by washing processes.

Because of lack of space only the conclusions of this interesting investigation can be here reported.

1 In general, no fixed value, such as can be given for mineral substances of definite chemical composition, can be given for the specific gravity of coal. Different types of coal, such as anthracite and bituminous, have different specific gravities, and even coals of the same general type may have quite different specific gravities, due to differences in content of ash and moisture.

2 Fresh coal of the Illinois type is probably saturated with moisture, most of which is held mechanically in the pores of the coal.

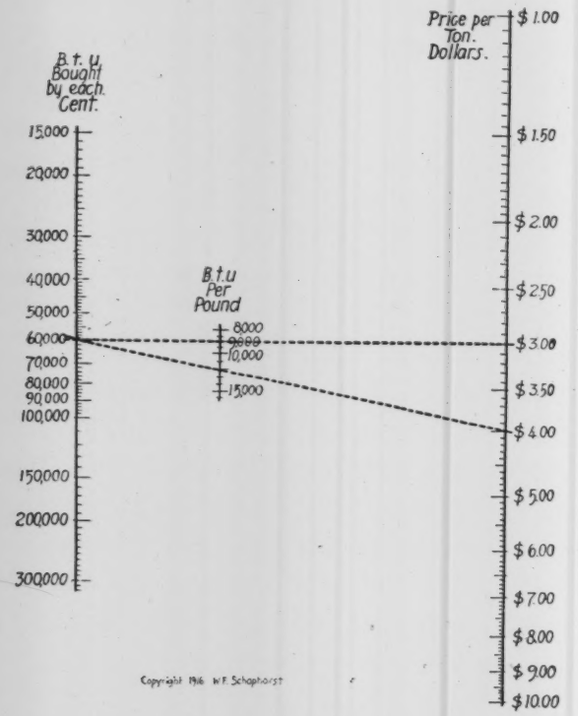


FIG. 6 CHART FOR DETERMINING THE COST OF COAL ON THE HEAT VALUE BASIS

3 The specific gravity of fresh coals of the same general types should be about constant if the content of ash is about the same. The specific gravity of coal in the fresh condition has been called the "fresh" specific gravity.

4 If coal has dried to any extent its specific gravity will vary, depending upon the amount of moisture lost. As the moisture content decreases, the specific gravity should decrease (the ash content remaining the same), but not necessarily in a direct ratio. The specific gravity uncorrect for moisture or ash content has been called the "apparent" specific gravity.

5 By calculating values of specific gravity to exclude the effect of moisture, values may be obtained which have been called the "real" or "true" specific gravity, and which might well be called the "dry" specific gravity to correspond with analyses of coal which have been calculated to the "dry" or "moisture-free" basis. By excluding both ash and moisture, values might be obtained which could be referred to as the "unit" specific gravity, to correspond with the unit coal B.t.u. of Parr.

6 By saturating air-dry coal with moisture before determining its specific gravity, a value can be obtained which represents quite closely the "fresh" value of the specific gravity, or the specific gravity of the coal in its fresh condition.

7 The fresh specific gravity of coal from different counties in Illinois was found to vary from 1.28 to 1.33, with an average of between 1.30 and 1.31. These values, excepting those for Vermilion and Montgomery counties, were obtained from air-dry coal by the approximate method described on page 20 of this bulletin.

8 In computing tonnages, it is suggested that (*a*) for coal in the ground, the fresh specific gravity is the proper value to use, (*b*) for broken coal stored under water, the fresh specific gravity should be used, and (*c*) for broken coal stored in bins or in open piles, the apparent specific gravity should be found for the average condition of the coal at the time the computations are made, and that value used.

9 In coal-washing operations the coal, theoretically, should be as dry as feasible when fed to the washing machines, since the settling ratios are considerably greater for dry than for wet coal, and dry coal can consequently be washed more efficiently. (*University of Illinois Bulletin,* vol. 13, no. 44, July 3, 1916, 49 pp., 9 figs. *e.*)

CLINKERING OF BITUMINOUS COAL, F. C. Hubley

Discussion of the factors that influence results of laboratory fusion of ash.

The writer states that the use of varying amounts of dextrin as a binder for the test piece appears to have considerable effect on the nature of the fusion and the final melting point. To investigate this factor thoroughly, a number of ash samples representing coals from different localities were mixed with various amounts of dextrin, and fusion curves developed along with the binder-free ash fusion. From these tests it would appear that if these fusiometer tests are in any way comparable with the Seger cone tests, the result of using binder in these cones is of so variable and marked a nature as to make the use prohibitive in fusion work.

In the specifications for a standard test, some mention should be made of the maximum amount of carbon to be allowed to remain in the sample after incineration, since comparatively small amounts appear to change the position of the final melting point, and the nature of the fusion. (*Power,* vol. 44, no. 17, page 591, October 24, 1916, 3 pp., 7 figs. *e.*)

CHART FOR DETERMINING THE COST OF COAL ON THE HEAT-VALUE BASIS

By special permission of W. F. Schaphorst, M. E., by whom it is copyrighted, we are enabled to reproduce a chart from which direct readings showing the cost of fuel on the heat-value basis, may be taken. In using the chart it is necessary only to lay a straight edge across the points on the scales corresponding to the price of the fuel in dollars per ton, and the heat value of the fuel in B.t.u. per pound, its extension across the third scale intersecting at a point which indicates the number of heat units compensated for by each cent invested in the fuel, which is the important factor for determination. (Fig. 6.)

For example, if the price of a given grade of fuel having a heat value of 9000 B.t.u. per lb. is $3.00, the chart will show that each cent of investment will pay for 60,000 heat units. Again, if the price of 12,000-B.t.u. coal is $4.00 per ton, it will be found from the chart that the cost on the heat-unit

basis is the same as before, that is, 60,000 heat units for each cent invested.

The $4.00 coal is therefore just as cheap as the $3.00 coal, and is likely to be the preferred fuel from the fact that its higher price indicates the possibility of less ash and other deleterious content. Should the heat value of this latter fuel be anything in excess of 12,000 B.t.u. per lb., there can be no question as to selection from the standpoint of economy.

The range of the chart is such as to be applicable to fuels ranging in cost from $1.00 to $10.00 per ton and from 8000 to 16,000 B.t.u. per lb. in heat value. (The chart is actually reproduced from the *Railway Review*, vol. 59, no. 13, p. 422, September 23, 1916, 2 pp., 1 fig. *d.*)

Hydraulics

HYDRAULIC FLOW REVIEWED, A. A. Barnes

The book is in two parts, the first of which deals with the flow of water in pipes and channels. The author had occasion to investigate certain conditions of flow in the Thirlmere Aqueduct which supplies water to Manchester, England, and, finding the variation in the coefficient of accepted formulae unsatisfactory, was led to review the whole subject of the laws of flow, with the result that he has devised a series of formulae in which the coefficient is independent of variations in the size or gradient of the conduit.

He shows that the equations of five well-known experimenters are all of the form $v = Km^{\frac{1}{2}}i^{\frac{1}{2}}$. He then points out that the square-root indices of m (the hydraulic mean depth) and of i (sine of slope) are incompatible with the constant value for the coefficient K for a particular class of pipe or channel. He recommends, therefore, the adoption of the more general expression $v = Km^a i^b$, and from the analysis of a considerable amount of published data assigns a series of values to K, a and b which give consistent and satisfactory results when applied to a wide range of cases. The formulae thus obtained are sixteen in number, and, for example, for new asphalted cast-iron pipes the value is $v = 174.1m^{0.769}i^{0.529}$.

In the second part of the book, dealing with the measurement of water by means of triangular notches, rectangular weirs, and circular orifices, the author discards the basic expression in common use and advocates the application of the general formula adopted in Part 1, which he casts in the form $v = Km^aH^b$. For a right-angled V-notch this becomes

$$v = 2.462m^{-0.00703}H^{0.48703}$$

$$\text{whence } Q = 2.48H^{2.48}$$

This latter expression corresponds very closely with the results obtained quite recently by Gourley and Crimp in researches made on the River Alwen. Their formula reads

$$Q = 2.48nH^{2.4}$$

where n is the tangent of half the included angle of the notch and therefore is unity for a notch of 90 deg.

The following formulae have been determined:

for weirs with end contractions:	$v = 3.324m^{-0.11}H^{0.38}$
for weirs without end contractions:	$v = 3.324m^{-0.03}H^{0.51}$
for circular orifices:	$v = 4.652m^{-0.015}H^{0.5}$

The author claims that his formulae are proved correct by experiments for quantities as small as 0.0034 cu. ft. per sec. by means of weirs. (Book, XI and 158 pp., published by E. and F. N. Spon, Ltd., London, 1916; cp. *Nature*, vol. 98, no. 2449, p. 87, October 5, 1916, 2 p. *g.*)

Machine Parts

NOTES ON PISTON-RING DESIGN, Gwilym Williams

Many facts enter into the attainment of the gas-tightness of piston rings:

1 The pressure per square inch exerted by the ring on the cylinder wall;
2 The uniformity of that pressure;
3 The practical degree of perfection obtaining in the manufacture of the rings.

Pressure per Square Inch. It is impossible to state definitely what pressure per square inch a given ring should exert under given conditions, as it is impossible to predict what part may be played by distortion of the cylinder and consequent leaks. Proper or improper fitting of joints, strain in springing over the piston, etc., have also to be considered. All that can be said is that 18 lb. is the upper limit today in aero engines working under high compression, and the average pressure of car-engine rings is 10 lb. per sq. in. What pressure is best suited to an engine is a matter to be decided by experiment. It is important because friction of the rings is roughly proportional to the pressure, and for instance, in an investigation of pressures exerted by the rings in a 3½-h.p. cycle engine, rings of 8 lb. per sq. in. were substituted for ones giving 11 lb. to the sq. in., with a resulting gain in speed of five miles per hour. The best is to adopt rings of minimum pressure compatible with gas-tightness, and many rings in use today are stronger than they need be.

The following formula for calculating pressures is accurate enough for all practical purposes and may be applied to concentric and eccentric rings alike. Let d be the outside diameter of the ring in inches, t the thickness opposite the joint, and l the length of the gap; then, assuming that the radial pressure of the ring is uniform,

$$\text{Pressure per sq. in.} = \frac{t^2\ l\ k}{d^4}$$

where k is an elasticity-section coefficient. For a ring of rectangular section of good cast iron it may be taken as 2,200,000.

From this it is evident that the pressure per square inch of the ring in designing may be varied in two ways, either by allowing a greater or less gap, or by proportioning the thickness. There is, however, a limit to the gap which a ring will stand, and it is desirable to avoid inordinately large gaps because the extreme fiber stress in the metal at the back of the ring, in closing, increases inversely as the square of the gap (there are also other reasons). What constitutes an average gap may be calculated from the formula:

$$\text{Length of gap in inches} = \frac{0.004d^2}{t}$$

It is misleading to arbitrarily proportion the gap as one-tenth or one-twelfth the diameter of the ring. The gap should be calculated on the basis of stress in the metal, which depends as much on thickness as on diameter.

The problem of adequate rings is of particular importance for aero engines, where thick rings cannot be used owing to piston weight. The rings must be of the thinnest permissible section, yet gas-tight; they must be flexible, to take up distortion of the cylinder, yet must exert sufficient pressure outwards to counteract centrifugal friction against the grooves in the radial types.

The author does not believe in the use of high-speed-steel rings in place of the ordinary obturator rings, even if liners are used in the cylinders, and thinks that the conditions that

give rise to these rings are being met by other means such as the adoption of aluminum pistons. These permit of deeper grooves than cast-iron or steel pistons, and with their overcoming of heat distortion, thin cast-iron rings, properly dimensioned to give the requisite pressure, will oust both obturator and high-speed-steel rings.

The even *radial distribution of pressure* exerted by the ring depends entirely upon the curve of the ring when free, and not upon eccentricity or concentricity. While eccentric rings do not fulfil the fundamental principle for which they have been originated, they have the advantage over concentric rings of flexibility towards the joints. The usual method of producing rings is by hammering, and internal hammering applied with the proper degree of precision will produce well-rounded rings; but as regards its effects upon the rings, the author states that internal hammering strains that part of the ring which is subjected to greatest stress when in the cylinder. It may be noted in this connection that the British Chuck and Piston Ring Co., of Coventry, have another method of hammering which is free from this objection. In their method the hammering is done on the part of the ring which is the least stressed when closed. The stress in the metal at the back of the internally hammered ring will be double that of the other. This point, however, must be borne in mind only in the case of special rings with large gaps. The majority of ordinary car-engine rings can be produced equally well by either method. (*The Automobile Engineer*, vol. 6, no. 95, p. 293, October, 1916, 2 pp., 3 figs., *g*.)

THE LATERAL BENDING RESISTANCE OF METAL BOLTS AND LAG SCREWS, Prof. H. A. Thomas

Summary of tests recently made at the Rose Polytechnic Institute, Terre Haute, Ind., to determine accurately the resistance of bolts and lag screws in wood to being bent by transverse loads.

The lag screws and bolts used were ordinarily mild steel, commercial stock, or sizes varying from ⅜ in. to ⅞ in. in diameter. The woods in which they were imbedded for testing were yellow pine, oak, and white pine. In the majority of the experiments the bolts or lag screws were free to bend, as shown in Fig. 7A, with no constraint on the shaft or head. In those tests in which the load was applied by means of a metal plate, as in Fig. B, the holes in the plate were made a little larger in diameter than the lag-screw shafts, and the lag-screw heads were screwed down to a very loose fit only.

Most of the tests were not carried to final failure. When a complete test was made, the failure was found to occur in five stages, illustrated in Fig. 6, which is the load-deflection curve from the test on the joint represented diagrammatically in Fig. B.

During the first stage *ab* in Fig. C, the load concentrates itself at point *A*, Fig. B, and the bolt beds itself firmly in the bolt hole if the initial fit is imperfect. During the second stage *be* the increasing load is carried by the elastic resistance of the wood fibers at *D* and the metal at *E*. The load-deflection curve is approximately straight during this portion of the test. This stage is terminated at the yield point *c* by the simultaneous yielding of the wood fibers at *D* and the metal fibers at *E*. During the third stage the deflection continues to increase with little or no change in the load. At the beginning of the fourth stage *de*, the bolt makes contact at *B* or *C*. The load again increases during this stage up to the beginning of the final failure at *e*. The last stage *ef* represents the splitting of the wood or the parting or pulling out of the bolts or lag screws.

In removing the bent bolts and lag screws from the wood after testing, it was noticed that the bend, point *E* in Fig. A, was in every case quite abrupt and not a gradual curve. The straightness of the bolts between the bend and the surface of the wood suggested the possibility of writing algebraic expressions for the resistance of the bolts to bending against the wood fibers on the assumption of a straight-line distribution of the stress on the wood fibers between points *E* and *D* in Fig. A.

Under such an assumption the following expressions were obtained: The sum of the vertical forces acting on the bolt is zero, or

$$w = \tfrac{1}{2}npad \quad \ldots\ldots [1]$$

The point of maximum bending is where the shear is zero, at the inner end of the stress triangle, and the bending moment at this point is

$$M = wa - (\tfrac{1}{2}npad)\,(2/3a) = 1/32f\pi d^3 \quad \ldots\ldots [2]$$

Solving these equations for w gives

$$w = \tfrac{1}{8}d^2\sqrt{3\pi n}\quad\sqrt{pf} \quad \ldots\ldots [3]$$

In order to adapt equation [3] to the use of the common safe allowable fiber stresses in wood and steel, a change in its form has been found desirable, due to the fact that if the ordinary safe allowable fiber stresses for metal and wood are substituted in equation [3] to obtain safe working loads for the design of connections, an unnecessarily large safety factor is secured.

Fig. D shows the moment-deflection curve from the test of a ⅞-in. round mild-steel bolt in cross-bending, and the stress-strain curve from the test of a similar bolt in tension. In a cross-bending test of a round bolt, the true proportional elastic limit will occur when the distribution of the stress on the governing section of the bolt is as shown by the straight line *aoa'* in Fig. E. At this instant the stress in the extreme fiber is equal to the tensile elastic limit *e* of the metal. When the loading has been increased until the distribution of stress approaches curve *abob'a'*, the bolt will deflect under a constant load; that is, the yield point of the material in cross-bending will be reached. In the first case, the resisting moment of the bolt is computed by

$$M_e = e\,\frac{\pi d^3}{32} \quad \ldots\ldots [4]$$

In the second case, the resisting moment is computed by

$$M_t = f\,\frac{\pi d^3}{32} = 4e\int_0^r + \sqrt{r^2 - x^2}\,dx = 4/3er^3 = ed/6 \ldots [5]$$

Solving,

$$f/e = 16/3\pi = 1.696 \quad \ldots\ldots [6]$$

That is, the yield point in cross-bending is 170 per cent higher than the yield point in tension. Substituting in equation [3] the value of f from equation [6], we obtain

$$w = 0.500d^2\sqrt{n}\sqrt{pe} \quad \ldots\ldots [7]$$

This equation gives the yield-point load carried by the bolt in terms of the end-bearing yield point of the wood fibers and the tensile yield point of the steel.

In order to make use of equation [3] or [7] in practice, it is necessary to know the value of n, that is, the ratio of the bearing resistance of wood against round pins to its resistance against square pins. A considerable number of tests were made to determine the value of this ratio. The values of n were found to be rather erratic, apparently depending much

on the friction of the wood fibers against the round pins, and being affected by the roughness of the pin, pitch or moisture in the wood, and the method of boring the hole. The average value of n in end bearing on the wood fibers from more than sixty tests was found to be 0.75. This value is used in equation [8]. To adapt equation [7] to the use of working stresses, let W be the safe load allowed on a bolt or lag screw bending against wood fibers, P the safe allowable bearing stress on wood fibers, and E the safe allowable tensile stress for metal. The final working equation for the design of bolted or lag-screwed timber connections may then be written

$$w = 433d^2\sqrt{PE} \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

This equation should be used only for lag screws or bolts of circular cross-section, of metal having a well-defined yield point, and bearing endwise against the wood fibers.

The notation in the above expressions is as follows: d = diameter of the bolt in inches; a = distance from the surface of the wood to the point of maximum bending, inches; w = load carried by the bolt at the instant of yielding, pounds; f = fiber stress in the metal of the bolt at its yield point in cross bending, pounds per square inch; p = yield-point bearing stress of wood fibers, pounds per square inch; n = ratio of the yield-point resistance of wood fibers in bearing against the side of a round metal bar to their resistance in bearing against a square metal bar of the same diameter and length. (*The Rose Technic*, vol. 26, no. 1, p. 6, October, 1916, 5 pp., 7 figs. *de.*)

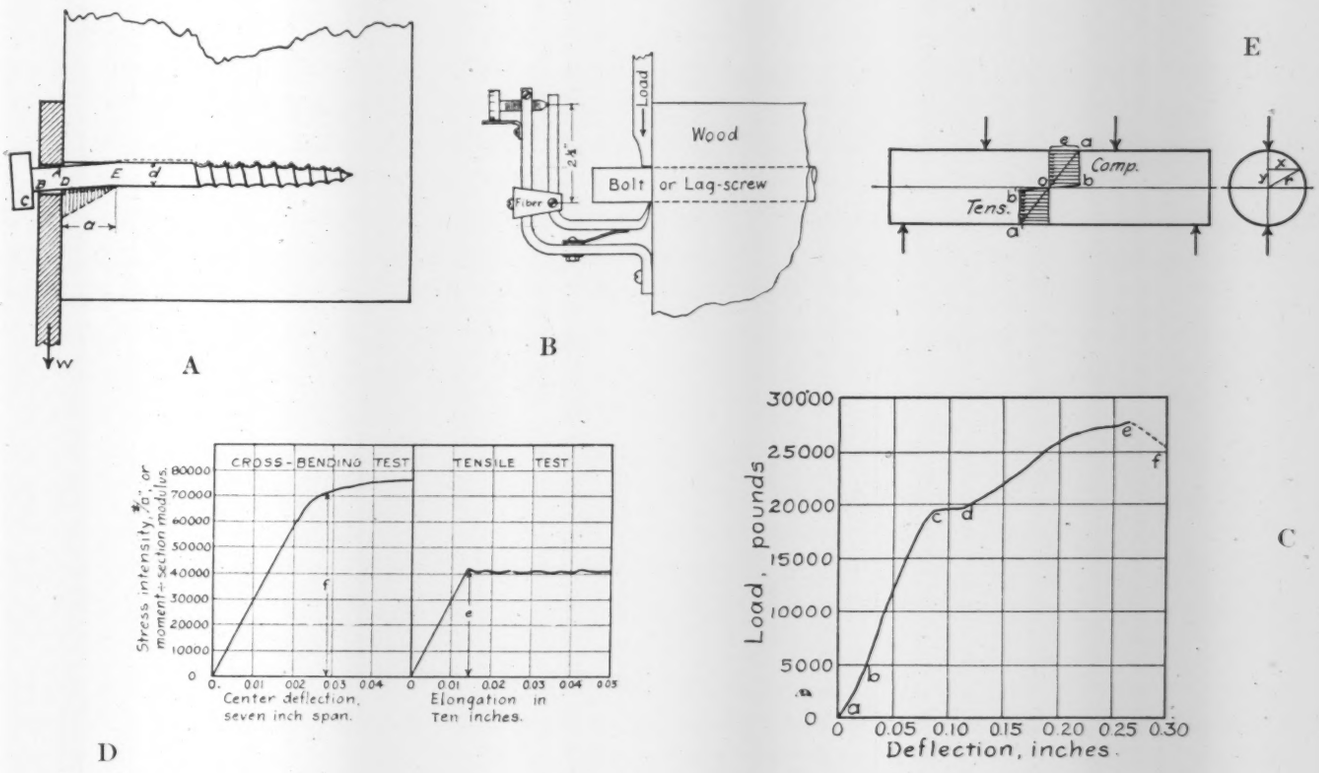


FIG. 7 LATERAL BENDING RESISTANCE OF METAL BOLTS

THE VICKERS SURFACE-HARDENING PROCESS

The Vickers process of local surface hardening is comparatively little known. It consists of applying momentarily to the surface of the part to be treated an intensely hot flame from an oxy-acetylene blowpipe. The effect of this is to raise the surface of the object to a high temperature, it being then immediately quenched by the cold body of the metal beneath.

The equipment is only that usually provided for the oxy-acetylene welding process, but the temperature of the oxy-acetylene flame is higher than that used for the latter process, the increase being obtained by adjusting the flame as for welding and then slightly increasing the supply of oxygen. Arrangements should be made for keeping the work as cool as possible, so that the body of the work is maintained at a low temperature to insure that the quenching is sufficiently rapid. For small parts it is customary to immerse the parts in a tank of cold water fitted with an adjustable overflow pipe. Bodies of large parts may be left to cool off by themselves, but where necessary a supply of cold water may be allowed to flow over the work. In both cases the actual surface to be hardened is not submerged in water unless it is desired to give only a very shallow depth of hardened case.

The process is most suitable for dealing with parts of which it is desired to surface-harden only a small portion. It is being largely used at the present time in England for gear-tooth hardening. In calculating the cost of the process for the purpose of comparison with furnace-treated work, it must be recognized that—whereas for the latter process it is customary for the machining of the work to be carried out to approximate dimensions only, so that any distortion due to the heat treatment may be corrected by straightening and grinding, or grinding alone, as the case may be—by the local surface-hardening process the work is machined to the actual finished dimensions, since there can be no distortion during the process.

In a paper read before the Institution of Automobile Engi-

neers, Mr. J. H. S. Dickenson, in November, 1915, pointed out that he had made several experiments to show the value of the process as applied to the local hardening of radii in parts subjected to high alternating stresses, and pointed out that the results of these tests went to prove that the limiting range of alternating stress in parts thus treated showed a considerable rise. Mr. Dickenson stated that, as a result, he was of the opinion that in the production of automobile crankshafts such local treatment of the radii had some obvious advantages. (*The Automobile Engineer*, vol. 6, no. 95, p. 299, October, 1916, 1 p., 1 fig. *d.*)

STRAINER FOR SUDS PUMPS

One outstanding feature of the usual troubles in supplying coolant to machine tools is the speed with which the usual

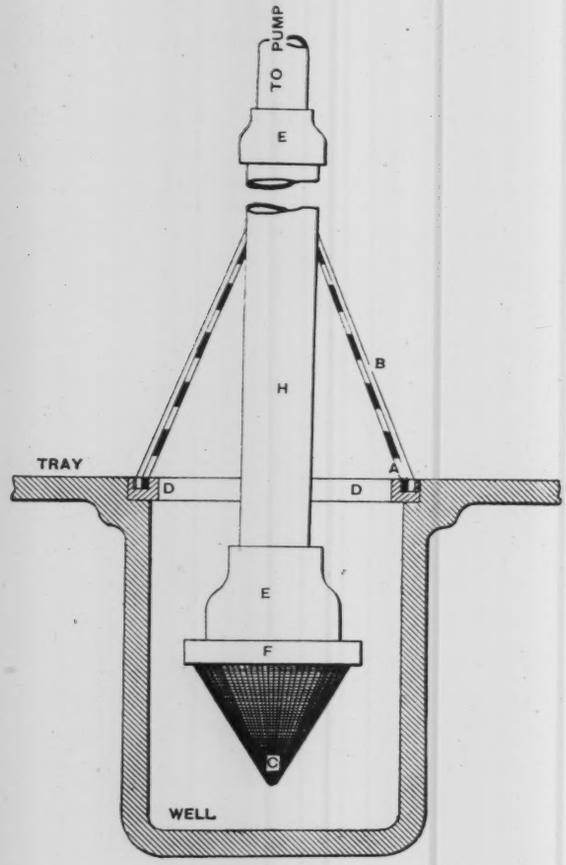


FIG. 8 STRAINER FOR SUDS PUMP

type of pump fails, owing to grinding out. The majority of such pumps have little provision of an effective type to keep the fluid clear of particles of metal, and very often the straining devices are so troublesome that they have to be discarded entirely. Often the suction pipe draws from a shallow well in the suds tray, and a piece of $\frac{1}{8}$-in. or $\frac{3}{16}$-in. plate filled with a number of small holes and fitting the well opening is the only provision for straining. Such a design chokes repeatedly and is finally discarded, which results in transferring the trouble to the pump, now void of any protection whatever.

A plate laid horizontally is in the worst possible position for choking, in addition to which the holes provided are much too coarse, so that finer particles of metal may pass. What is necessary is that the strainer plate shall be vertical or inclined, and not laid flat. Further, since the holes now provided are too large, it is better to use fine wire gauze inclined at an angle of 45 or 60 deg., in which case choking would take place line by line, and clearing be less frequent. As gauze by itself is liable to damage, it has to be reinforced, which can be done by a small-mesh galvanized expanded metal known as cup lathing. The strainer can be either cylindrical, or, better still, an inverted cone. The accompanying sketch shows the writer's suggested solution. An additional improvement can be made to most pumps by an enlargement of the suction-pipe area. Suction head is harder on a pipe than delivery head, and for this reason most well-designed pumps have larger suction than delivery. In the sketch (Fig. 8) *D* and *F* are brass rings, grooved to receive the larger end of the cones made by the brass-wire gauze and galvanized expanded metal in combination. To give a neat appearance to the upper end of the cone, the points of the expanded metal can be cleated over the gauze, or a brass ring of similar construction to *D* and *F* can be used. The ring *F* is screwed internally, and connected to the reducing socket *E* by means of a short screwed nipple. In the tray strainer, *B* represents the gauze and *A* the expanded metal. The total clear head of the suction pipe, without obstruction, should be twice that of the strainer cone. Removal of the cone and suction pipe allows the well to be thoroughly cleaned out, and if such a removal is made an easy matter, it is likely to receive due attention. If the suds pump be fitted, say, 18 inches above the level of the well, the cone strainer can at any time be fitted for easy access to the wall for clearance. The suggestion has, moreover, the advantage that it is easily fitted to the majority of existing jobs at a trifling cost. *Machinery* (London), vol. 8, no. 211, p. 871, October 12, 1916, 1 p., 1 fig. *d.*)

Munitions

UNITED STATES MUNITIONS—THE SPRINGFIELD MODEL 1903 SERVICE RIFLE

Continuation of the article abstracted in The Journal, November, 1916, p. 936. This issue describes the manufacture of a fixed base and the final barrel operation. The article is profusely illustrated by drawings, and will be of great assistance to those who may have to engage in the production of the Springfield rifle.

Among other things is described in detail the operation of browning rifle barrels, as well as the making up of the so-called browning solution. The article also describes and illustrates special machines built to take care of operations which are difficult to perform on a standard machine tool, and also inconvenient to perform by hand. One such operation is the smithing of the bevel seat for the windage screw, for which a special machine has been designed and built at the Springfield Arsenal.

Some of the fixtures made at the Springfield Arsenal are, in fact, so elaborate in design as to approach special tools in complexity. The writer draws attention to the fact that it is hard to draw the line in some instances between a special tool and a complicated fixture. This is particularly true regarding the inspecting fixtures. Many of these are beautiful examples of the toolmaker's art, and require a high-grade skill on the part of the rifle-shop tool room. (*American Machinist*, vol. 45, no. 17, p. 725, October 26, 1916, 10 pp., 81 figs. *dA.*)

Railroad Engineering

WHAT EFFECT DOES THE MECHANICAL PLACING OF FUEL IN FIREBOXES AND LUBRICATION OF LOCOMOTIVES HAVE ON THE COST OF OPERATION?

Report presented at the Convention of the Traveling Engineers' Association, held at Chicago on October 24, 1916, by a committee—W. L. Robinson, chairman.

The average tractive power of all locomotives in the United States has increased in the past ten years 38.6 per cent, the heavy locomotives of years ago, ranging from 36,000 to 42,000 lb., having given place to those ranging from 54,000 to 160,000 lb., and the figures increasing yearly. The average of tons handled per freight train has increased 54.1 per cent in ten years. As the amount of coal consumed by a locomotive for a trip became very large, some roads using this heavy power found serious difficulty during the summer months in retaining experienced firemen in service. Therefore, if the heavy-tonnage trains were to be a success and the cost of operation held to a minimum, the necessity for the "iron fireman" was apparent.

The following figures covering the four railways using the largest number of locomotives with appliances for feeding fuel mechanically, and by which a large proportion of their freight traffic is handled, show interesting comparisons of average train loads. These figures are taken from reports made to the Interstate Commerce Commission, which, among other things, comprise figures showing that the locomotive fuel cost per ton-mile on each road shows a decrease for 1915 as compared with 1904.

TABLE 4. FISCAL YEAR ENDING JUNE 30, 1915, COMPARED WITH FISCAL YEAR ENDING JUNE 30, 1904.

	Increase in Average Tractive Power, Per Cent.	Increase in Average Number of Tons of Freight Per Train Load. Per Cent.
Road A	43	78
Road B	40	72
Road C	30.7	72
Road D	29	54

The report discusses further the firing of coarse and pulverized fuel by mechanical means, and concisely indicates the results that are being obtained. The following is of particular interest.

The experience of most roads is that better time is made with the same tonnage on the same grade than with hand-fired engines.

The necessity for shoveling coal ahead by laborers is eliminated at intermediate points where, during the warm months, it had been necessary with hand firing.

It has been the experience of some roads that when the appliances and fire are properly handled, grate shaking between terminals is not necessary. The thinner fire makes it possible also to save time in cleaning fires. Fewer failures are the rule, due principally to ability to largely overcome defects, such as leaky superheater units, firebox sheets, flues, cylinder packing, valves, etc., which often result in hand-fired locomotives setting off trains.

Grades of coal such as nut-pea-and-slack, or screenings, can be utilized successfully (cp. Table 5). However, except in the case when the haul would be small, the use of low-volatile screenings is undesirable, due to their slower-burning properties and resultant loss through fuel being drawn through the flues and out of the stack when the locomotive is being worked to capacity.

Maximum steam pressure can be maintained at all times. This has been stated by a railroad officer following up locomotive operations on a large road, in the following words: "The engineer does not have to consider the fireman, but can 'beat' the engine all he desires, as the fireman is made of 'iron.'"

The maintenance of the maximum rate of steam production, utilizing full boiler capacity over extended periods at points where the maximum effort of the locomotive is required, has been a most potent factor in the improvement in the handling of trains.

(*Railway Review*, vol. 59, no. 18, p. 588, October 28, 1916, 3 pp. *g.*)

ADVANTAGES OF SUPERHEATERS, BRICK ARCHES, AND OTHER MODERN APPLIANCES ON LARGE LOCOMOTIVES, ESPECIALLY THOSE OF THE MALLET TYPE

Report presented at the Annual Meeting of the Traveling Engineers' Association, at Chicago, last September, by a committee, J. E. Ingling, chairman.

The report covers a wide field in an interesting manner. Owing to lack of space, only the parts of greatest interest to the body of mechanical engineers can be abstracted. The report emphasizes the triumphant progress of superheating in locomotives, and especially the fact that the superheater equipment has been fully standardized and is almost identical on the 12,000-13,000 locomotives now operating in the United States and Canada.

TABLE 5.

	Gas.		Soft or low volatile	
	Nut-pea-slack.	Slack.	Run-mine.	Screenings.
Basis per h.p.-hr	3.88	4.23	4.32	5.17
Lb. coal—relative lb. coal	100.00	109.00	111.19	132.98

NOTE.—Nut-pea-slack—Coal, passing through a 1¼-in. bar screen.
Slack—Coal, passing through a ¾-in. bar screen.

The locomotive boiler, when considered for the application of a superheater, presented many limitations that necessarily had an important bearing on the design and the construction of the superheater. The locomotive boiler is in no case larger than is absolutely necessary, and, in the majority of cases, is even insufficient in evaporating surface. The application of the superheater necessitates a further reduction of about 15-20 per cent in the tube heating surface, occasioned by the use of the large flues in which the superheater units are located. In addition to this, a certain percentage of the gases which formerly were available for evaporation of the water must now be used for superheating the steam, since the superheater does not provide for any increase in the maximum rate of combustion. Nevertheless, with all these deficiencies, the superheater designer has been able to produce an economy of 25 per cent in fuel. The curves of Fig. 9 give an illustration of what has been done and may be expected to be done in the near future. The curves show cylinder tractive effort in per cent plotted against piston speed. The lowest curve represents the speed factor for an average superheated-steam locomotive. The next curve does the same for the average modern superheated-steam locomotive using between 200 and 250 deg. of superheat.

But the superheater engineer has only made use thus far of the same flue sizes as were used by the locomotive designer for tube sizes. With the use of a size different from the two present standards, it is, however, possible to obtain in a superheater boiler an evaporating surface practically as great as in the saturated-steam boiler. In this case the superheating

surface will be a net gain to the heat-absorbing surface of the boiler, and a greater capacity may reasonably be expected. The top curve shows approximately what may be confidently looked forward to in the near future. For some time past large passenger locomotives have been operated very successfully with steam-chest temperatures running between 750 and 800 deg. fahr. The top curve in Fig. 9 is representative of locomotives using this degree of steam-chest temperature, which means 350-400 deg. of superheat.

From superheater-locomotive experience it has been found that the pyrometer is a great aid to engineers and firemen in determining just how much superheat they are getting. In fact, as a railroad man states, what the duplex air-brake gage is to the brake system, the pyrometer is to the superheater. In one case, on an engine just turned out of the shop, where a superheater had been applied, during the first few trips there was no trouble to get a reading of 630 deg., but after a few trips the readings decreased until they finally fell back to 580 or 590 deg. This showed at once how necessary it is to keep the flues absolutely clean of all cinders and sparks in order to get the full benefit of the superheat. On another occasion the engineer who had a pyrometer on the engine was getting along nicely with a reading of about 600 deg., when the engine

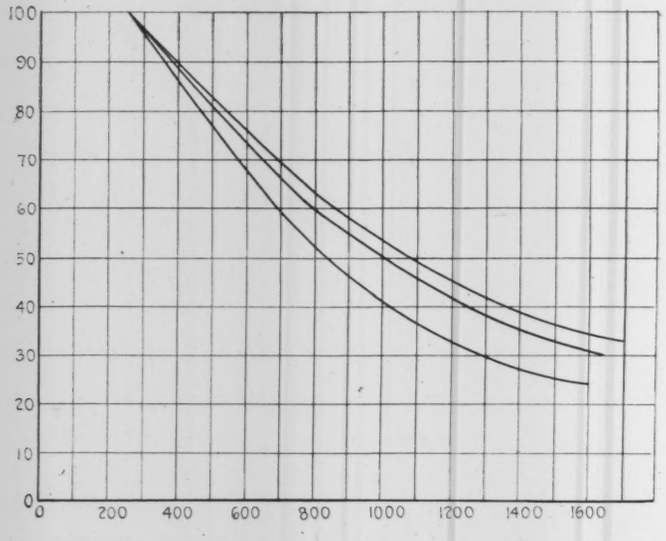


FIG. 9 BOILER EFFICIENCIES WITH AND WITHOUT SUPERHEATER

started to foam and the superheater dropped back very rapidly. This indicated to the engineer the importance of keeping the water down to a safe level, to prevent the working of water through the superheater.

In the matter of brick arches, the committee states that the arches are now applied to get more power without increasing fuel consumption, whereas formerly they were used to reduce the fuel consumption for the same power output. The arch increases the boiler capacity directly by aiding combustion and by reducing the heat losses, and thus increases boiler efficiency, which latter is a thing that a superheater cannot do. The committee gives a chart indicating what efficiency may be expected when using a good quality of bituminous coal in a modern high-pressure superheater locomotive (Fig. 10). This chart shows that the efficiency of the arch increases as the rate of combustion or the amount of coal burned per square foot of grate area per hour. This is due to the fact that as the rate of combustion increases, the boiler efficiency decreases and the heat loss increases, thereby increasing the field of usefulness of the arch. The dotted line shows the boiler efficiency without arch, while the solid line above shows the boiler efficiency with the arch, the distance between the two measuring the efficiency of the arch as a fuel saver or capacity increaser.

As the chart shows, the heat losses due to imperfect combustion, or CO, range from 0.5 to 5 per cent, while the loss due to sparks varies from 2 to 16.5 per cent. These are the averages of a large number of tests. Tests indicate also that, at a rate of combustion of 100 lb. of coal per sq. ft. of grate area per hour, the arch will effect a reduction of 42 per cent in spark losses, equivalent to an increase of boiler efficiency of 7 per cent. As to smoke production, reports from many roads indicate that a decrease of 50 per cent can be obtained by the use of the arch, and on most roads the brick arch, with proper firing instructions proved sufficient to overcome objectionable smoke and to keep within the law.

Aside from this, the brick arch is now recognized as being an important factor in reducing flue failures due to flues

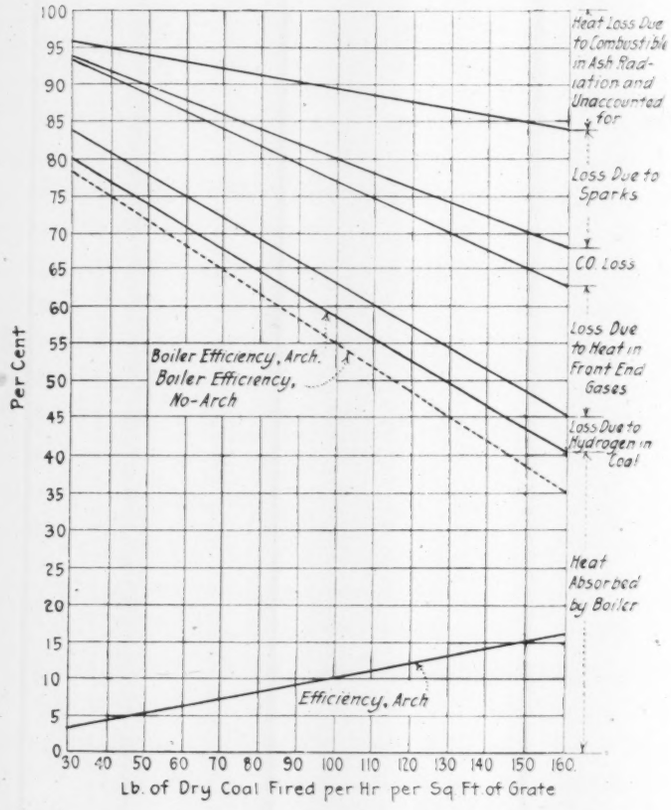

Per Cent
Heat Loss Due to Combustible in Ash Radiation and Unaccounted for
Loss Due to Sparks
CO Loss
Loss Due to Heat in Front End Gases
Loss Due to Hydrogen in Coal
Heat Absorbed by Boiler
Boiler Efficiency, Arch.
Boiler Efficiency, No-Arch
Efficiency, Arch
Lb. of Dry Coal Fired per Hr. per Sq. Ft. of Grate

FIG. 10 LOCOMOTIVE BOILER EFFICIENCIES WITH AND WITHOUT ARCH

plugging and honeycombing. (*The Traveling Engineers' Association.* Advance Copy of Committee Reports and Subjects for Discussion, 28 pp., 10 figs. *gd.*)

Steam Engineering

STANDARDIZATION OF BOILER OPERATING CONDITIONS

Description of the Aurora, Elgin & Chicago Railroad power station, and the boiler-house operation and equipment of same.

The power station has a total capacity of over 19,000 h.p., and supplies current to several interurban railroad lines, and also light and power to a number of small cities lying along these lines.

Of particular interest in this description is the part refer-

ring to the operation and equipment of the boiler plant. Subsequent to the appointment of a boiler-room foreman three years ago, the boiler-room efficiency has been increased 40 per cent, a result all the more remarkable that it was attained practically exclusively by the application of good sense and system in operation.

Before any tests were attempted each boiler received a thorough scouring, and scale was removed completely—for the first time in some tubes. Combustion chambers and breechings were the next to receive attention, with the result that many barrows of soot and dust were removed. An inspection showed that the front baffles of several boilers had shifted, and these were correctly reset. Operating tests disclosed the fact that in some of the boilers combustion was imperfect. By adding one or two rows of tile to the first baffle, and thus reducing the flue-gas velocity, the combustion was materially improved.

Draft and CO_2 values and thickness of fire were investigated and standard values adopted. Differential draft gages were installed on each boiler, an Orsat instrument and a continuous CO_2 recorder were provided, which could be connected to any boiler, and portable steam-flow meters were placed on several of the boilers.

Extensive evaporation and fuel-consumption tests applied to all the boilers showed that the best results were obtained when the draft over the fire was approximately one-third that at the damper, or about 0.32 in. and 0.95 in., respectively. A fuel-bed thickness of 5 in., 12 per cent of CO_2 at the damper, and boiler operation at 200 per cent rating were standards adopted as a definite basis of operation.

All boilers are subjected regularly to an evaporation test to determine their condition, and a record of this test is placed on file in the boiler-room foreman's office.

On one-half of the boiler-room log sheet are recorded the customary data, such as line diagrams of boilers in full service and boilers banked, total number of boiler horsepower hours, boilers down for inspection and repair, details of repair and approximate time required, number of men working on coal and ashes, number of repair men, kinds of coal being used, tons of coal, total B.t.u., and weightometer readings.

Placed in one section of the remainder of the sheet are the hourly readings of stack draft, outside and inside temperatures, and minimum steam pressure. In another section are recorded such constants as total hours' run of coal conveyor, average tons of coal handled per hour by the conveyor, total lb. water, total lb. coal, total B.t.u., total kw-hr. output for the day, maximum ½-hour peak in kw., kw. per boiler h.p. rating at peak, lb. water per lb. coal, lb. water per kw-hr. output, lb. coal per kw-hr. output, B.t.u. per kw-hr. output, and average load factor based on ½-hour peak.

In the office of the boiler-room foreman, besides the usual indicating instruments, there is a six-pen graphic recorder which indicates when and how long the coal- or ash-system motors were in operation; when and how long pop valves and blow-off valves were open; when the damper regulator was shut tight, and when the heater overflowed.

A feature of great importance in the carrying out of the system adopted is its permanence, in that the system is enforced rigidly and all the time. (*Practical Engineer,* vol. 20, no. 21, p. 907, November 1, 1916, 5 pp., 7 figs. *d.*)

Safety-Valve Areas, J. E. Terman

This is part of a general article, Visits of Inspector Brown, and is devoted to the matter of safety valves. The writer discusses the various formulæ for safety-valve areas, and compares them by means of the diagram Fig. 11. The three lower lines represent the requirements of the Massachusetts formula, United States Government rule, and the Philadelphia rule, or on the basis of 9 lb. of water evaporated per pound of fuel, and 16 lb. of fuel burned per square foot of grate per hour. The heavy line above that represents the requirements of the Canadian rule for all conditions, regardless of how the possible rate of driving may vary.

The three top lines represent the requirements of the Massachusetts formula, the United States Government and Philadelphia rules, where 32 lb. of fuel are assumed to be burned per square foot of grate per hour, 9 lb. of water being assumed to be evaporated per pound of fuel as before. The heavy offset line running across the sheet represents the values as given by the Massachusetts tables for safety valves, which in reality is the Massachusetts rule for safety valves, since the formula on which these tabular values are based is never used for determining the size of safety valves for use on boilers in Massachusetts. The two dotted lines, the lower of which represents the values by the United States Government rules, as mentioned, and the upper represents the minimum

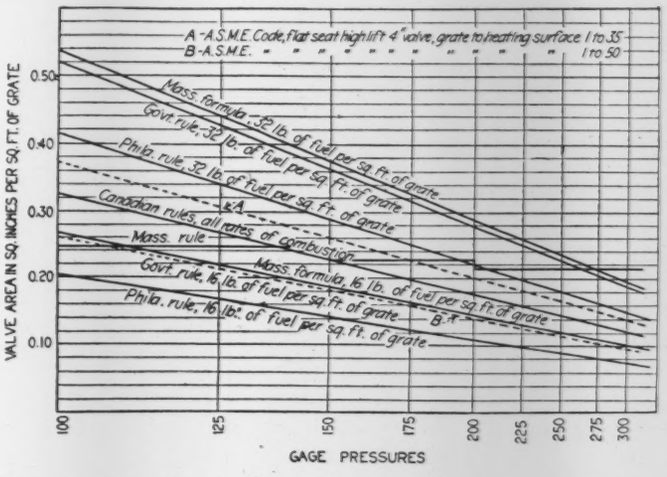

A-A.S.M.E. Code, flat seat high lift 4" valve, grate to heating surface 1 to 35
B-A.S.M.E. " " " " " " " " " " 1 to 50
Mass. formula, 32 lb. of fuel per sq. ft. of grate
Govt. rule, 32 lb. of fuel per sq. ft. of grate
Phila. rule, 32 lb. of fuel per sq. ft. of grate
A
Canadian rules, all rates of combustion
Mass. rule
B
Govt. rule, 16 lb. of fuel per sq. ft. of grate
Mass. formula, 16 lb. of fuel per sq. ft. of grate
Phila. rule, 16 lb. of fuel per sq. ft. of grate
VALVE AREA IN SQ. INCHES PER SQ. FT. OF GRATE
0.50
0.40
0.30
0.20
0.10
100
125
150
175
200
225
250
275
300
GAGE PRESSURES

FIG. 11 CHART OF SAFETY VALVE FORMULA REQUIREMENTS

valve area required per square foot of grate surface by the A. S. M. E. Boiler Code rule, on the assumption that a 4-in. valve with the maximum lift and with a flat seat is used, and that the ratio of grate to heating surface is 1 to 50 in. in the case of the top dotted line, and 1 to 35 in. in the case of the bottom dotted line, which coincides with the line representing the Government formula with an assumed rate of combustion of 16 lb. of fuel burned per square foot of grate per hour.

It is impossible to show a real comparison between the Code rule and the other rules, for the Code takes into consideration the actual discharge area of a valve—that is, how high it lifts—but all the other rules are based on the nominal area of the valve regardless of its lift. The Government rule and the Philadelphia rule take into consideration the actual amount of fuel burned on the grate, but the Massachusetts rule, as given in the table for determining the size of safety valves, arbitrarily fixes the amount of fuel with certain variations in pressure. (*Power,* vol. 44, no. 17, p. 587, October 24, 1916, 3 pp., 1 fig. *gc.*)

For the Cario formula for safety valves with high lift, the German police requirements, and a proposed improved formula see The Journal, August, 1915, p. 481).

BOILER CORROSION BY MAGNESIUM CHLORIDE, James Scott

One of the substances occurring in water and either forming scale or directly attacking the metal, is magnesium chloride. This substance exists practically exclusively in a state of solution.

The primary sources of magnesium chloride are magnesium limestone (or dolomite) and magnesium carbonate (or magnesite), together with chlorine usually derived from the decomposition of animal remains. Such combinations can be carried dissolved in water for many miles. Rain in descending through the soil and sub-soil extracts these elements, which are then chemically resolved into magnesium chloride. This salt is particularly evident in sea water and spring water. Unlike other salts, magnesium chloride does not separate out of its solution by boiling; instead, when a solution of magnesium chloride is boiled, the salt is decomposed into its primitive constituents, magnesia and hydrochloric acid or chlorine, and that is what gives it the dangerous power of attacking the boiler shell. If a solution of magnesium chloride be heated or evaporated, there remains a white film which is practically magnesium oxychloride. This, too, at once begins to dissolve in the moisture it draws to itself.

When magnesium chloride held in solution in boiler water is heated, its magnesia combines with the oxygen of the water and releases the chlorine, which is expelled above the general surface and combined with the hydrogen of the ascending vapor, thus forming hydrochloric acid, which immediately on contact with the metal begins the process of corrosion.

To obtain magnesium chloride in a more stable condition it is necessary to mix with it another salt such as ammonium chloride (sal ammoniac). When magnesium chloride is present the boiler plates above the water line and the condenser tubes are the parts most likely to be affected. Usually the continuous attacks form a brownish-red ferric chloride, which is capable of crystallizing when quite pure. It resembles rust in color. There is, however, an intermediate stage in which the salt occurs as red-green crystals, which merge off into shapeless brown-green particles.

This particular corrosion would be conspicuous were the boiler emptied and the metal dried. As a rule it remains in solution, being then really even more active in an objectionable sense. The disturbed metal finally wears down into a fracturable state.

If given an opportunity the magnesia would settle as a white powder, but only a chemical test can distinguish it from lime, which is similar to it to the naked eye. A good test is to add to a solution of magnesium chloride a little silver nitrate. An insoluble precipitate of silver chloride is then formed, which turns purple or black in daylight. (*Railway Engineer*, vol. 37, no. 441, p. 235, October, 1916, 3 pp., 3 figs., *g.*)

NEW FREMONT, OHIO, POWER PLANT, Warren O. Rogers

The new power plant of the Ohio State Power Co., near Fremont, Ohio, is practically completed. In the turbine room there are three 6250 kv-a. 4000-volt turbo-generators. The steam pressure carried is 250 lb., superheated 125 deg. The main turbines are operated without providing an atmospheric exhaust in case the vacuum should be lost. The turbines and condensers are protected against excessive steam pressure, in case of the vacuum falling below about 8 in., by a specially designed balanced valve, automatically controlled by the vacuum in the discharge outlet of the turbine. The operation of the valve is simple, the vacuum acting against the pressure of a spring. The vacuum acting on a diaphragm holds the valve open while the turbine is running. The spring holds the valve closed when the turbine is not running, or in case the vacuum falls below that necessary to hold the valve open. In order to start the turbine, the condenser air pump must be got up to speed so as to create a vacuum sufficient to open the automatic valve. If the vacuum is lost, the valve immediately stops the flow of steam to the turbine.

Each boiler furnace is equipped with a four-retort underfeed stoker. In the general design of these stokers, an improvement has been incorporated in that an automatic self-cleaning clinker attachment has been applied. It consists of a revolving ash grate operated by a ratchet, the speed of which is adjustable so that any desired regulation can be made to the movement of the cleaning device.

A network of piping for the condenser system has been eliminated by putting in a simple system by which the turbine driving the condensing apparatus receives steam from the 8-in. steam line that supplies the main turbine through a 1½-in. steam pipe that is tapped into the main line above the throttle valve.

Operated in connection with the steam units is a water-power plant containing three 4000-volt three-phase 60-cycle generators, driven by a 1900-h.p. water turbine operating with a 40-ft. head. (*Power*, vol. 44, no. 17, p. 576, October 24, 1916, 7 pp., 13 figs. *d.*)

Varia

THE EMPLOYMENT OF WOMEN IN GREAT BRITAIN

The data in the article abstracted here are taken from a book entitled Credit, Industry, and the War, containing reports and papers presented to the Section of Economic Science and Statistics of the British Association at its Manchester meeting in 1915.

It contains the results of inquiries arranged by the same Section during the current and past year, and is of particular interest because of the great care taken in the carrying out of the investigation.

As regards the work of women under war conditions, the committee which dealt with this subject writes:

"Summing up on this whole question of the extent of the replacement of men by women, it may be said that only in rare instances are women actually to be found performing the same work as was done by highly trained and specialized men. In general, the employment of females is confined to work of a repetitive or routine kind, the degree of skill necessary for which can be acquired after a short period of training. But the ability which has been shown by women on such work shows that, under different conditions, they might be able to do much more responsible work."

TABLE 6 EMPLOYMENT OF WOMEN ON SCOTTISH RAILROADS

Company.	Number of women employed before war.	Number employed since August, 1914.	Total number now employed, Oct. 30, 1915.
A	733	451	1,184
B	393	265	658
C	120	30	150
D	41	27	68
E	473	205	678
Total	1,760	978	2,738

SCOTTISH RAILWAYS AND THE EMPLOYMENT OF WOMEN

Dealing with the replacement of men by women in industry, the committee report appeared in Table 6 in regard to the Scottish railways.

"From statistics supplied by companies A and B, it is clear that the numbers have largely increased since October 30, 1915, and it may be accepted that the employment of women has advanced by 100 per cent from what it was before the war.

"The following figures may be given as making clear the general position in the railways:

COMPANY "A."

Department.	Women employed previous to war.	Number employed since outbreak.	Total number employed on May 8, 1916.
Accountants	14	7	21
Audit	23	4	27
Canal	4	5	9
Coaching	175	346	521
Joint line	7	...	7
Engineering	4	4	8
Factors	4	...	4
Goods	47	103	150
Head office charwomen	67	...	67
Hotels and refreshment rooms	246	58	304
Laundry	56	7	63
Locomotive	7	25	32
Solicitors	4	1	5
Stores	18	29	47
Telegraph	57	50	107
Total	733	639	1,372

"'Coaching' is the only department that relates definitely to transport: it comprises ticket collectors, booking clerks, carriage cleaners, and porters. Of these, carriage cleaners and booking clerks are the only grades not included in the agreement come to on August 16, 1915, between the companies and the National Union of Railwaymen: there were women carriage cleaners before the war, and there were a few booking clerks. Other grades are paid at the minimum rate paid to men: in one company the carriage cleaners are all paid at the old rate—12s. for a working week of fifty-four hours, with a war bonus of 3s.; while in another they are now paid the minimum men's rate. The same applies to booking clerks in the same companies. But ticket collectors and porters are paid all over at the minimum rate at the men's grade, the former receiving in a representative company 21s. per week, with a war bonus of 4s. In the "A" company there are now 54 women serving as ticket collectors; in the "B" company, 57. They work the same hours as men, and have early and late duty. In company "A" there are now 93 women porters, in "B" there are 58. These are said to be largely drawn from the class of women accustomed to heavy work, such as farm servants and fish girls; while the ticket collectors and booking clerks are drawn from warehouses and shops. There is a large demand for work in connection with these two railway companies that have their headquarters in Glasgow. In company "A" there were 58 women carriage cleaners before the war; now there are 191. They work from ten to eleven hours per day, with two hours off for meals; the working week is six days. At one station there are day and night shifts; elsewhere there are day shifts alone. The quality of work done is stated to be as good as the men's, but the quantity is not the same, especially that in the inside of the carriages. In company "B" there were 31 women carriage cleaners before the war, while there are now 115 (May 31, 1916). They work ten hours, less two meal hours, taking early and late duty alternately. At present they have no night duty. The quality of their work is said to be an improvement on the men's, but the quantity is a little less. Twenty-four are now cleaning the outside of locomotives 'to the satisfaction of the company.'

"Opinions differ as to the work of women on the railways. One authority of wide experience expressed his conviction that three women are needed for every two men employed in a work like carriage cleaning—not that three women would take the same time as two men, but two women would not suffice, and a third would need to be employed. The same authority also held to it that women could not, for physical reasons, work the same hours as do men in strenuous employment; and would prefer, as experience had taught him, shorter hours and less pay. But others again stated their conviction that what women lacked in quantity of work they made up in quality; and expressed their surprise at the amount of work women could get through, if they had sufficient wages to feed and clothe themselves properly.

"As in the case of the tramways, time is needed to show whether women can undertake the same hours and duties as men as carriage cleaners, ticket collectors, and booking clerks; or whether changes must be made to allow of their partial employment. It is hardly likely that they will wish to continue as porters; the work is too heavy even for the few.

"Women were admitted to the Railwaymen's Union two years ago, and 'quite a few' have joined." (*Railway News*, vol. 106, no. 2752, p. 401, September 30, 1916, 2 pp., *gs.*)

It is announced that the six leading engineering societies of the German Empire, with a collective membership of about 44,000, have amalgamated "for the purpose of confronting the great new tasks which now so urgently require to be coöperatively solved." The new association will be known as the Deutscher Verband technisch-wirtschaftlicher Vereine.

Detecting the presence of internal defects in iron and steel castings is accomplished by a current which is supplied from a small alternator to the primary of an induction coil, and which induces in the secondary a current which is passed through the coils of two horseshoe magnets mounted at a fixed distance apart and movable to and fro over the surface of the casting. The fields of both magnets will be affected uniformly if the structure is homogeneous. Defects, however, will disturb the lines of force from the nearest magnet. In a vibrating sounder, connected to a secondary coil on the magnet, the tone produced will differ in pitch from that given out from the corresponding sounder on the other magnet. Amplification of sound is secured by microphone attachments, enabling the observer, by means of telephone receivers, to detect the locality of hidden flaws as the magnets are moved over the casting.—*Mechanical World*, Oct. 6, 1916.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

THE AMERICAN AIRCRAFT RIGID DIRIGIBLE. Aircraft, vol. 7, no. 3, October 1916, 3 pp., illustrated.

DÉTAILS RELATIFS AU BALLON QUI FIT PÉRIR LES INFORTUNÉS PILATRE DE ROZIER ET ROMAIN LE 15 JUIN 1785, Dutertre-Yvart. L'Aérophile, vol. 24, no. 17-18, September 1-15, 1916, 3 pp., illustrated.
Details of the disastrous ascension of the Montgolfier balloon on June 15, 1785.

AIRCRAFT MOTORS, O. E. Hunt. The Michigan Technic, vol. 29, no. 3, October 1916, 8 pp.

AIR MACHINERY

HIGH-PRESSURE AIR-COMPRESSORS, Joseph M. Ford. Engineering, vol. 102, no. 2651, October 20, 1916, 3 pp., 11 figs.

RECENT IMPROVEMENTS IN AIR COMPRESSORS. Mine and Quarry, vol. 9, no. 3, October 1916, 5 pp., illustrated.

AUTOMOBILES

PRACTICAL ENGINE RATING, Edward G. Ingram. The Automobile, vol. 35, no. 17, October 26, 1916, 3¾ pp., 4 figs.

HOW WEIGHTS ADD POWER, HUDSON BALANCE SYSTEM CUTS DOWN FRICTION—PERMITS HIGH ENGINE SPEEDS AND GREATER RANGE. Automobile Topics, vol. 43, no. 12, October 28, 1916, 2 pp., illustrated.

GLOSSARY OF TERMS USED IN SPECIFICATIONS. The Commercial Vehicle, vol. 15, no. 7, November 1, 1916, 3½ pp.

VACUUM BRAKE FOR AUTOMOBILES. The Automobile, vol. 35, no. 18, November 2, 1916, 1½ pp., illustrated.

HUDSON ENGINE IN TEST RUNS. The Automobile, vol. 35, no. 17, October 26, 1916, ½ p., illustrated.

CONVENTIONS

TRAVELING ENGINEERS' ASSOCIATION CONVENTION. Railway Age Gazette, vol. 61, no. 18, November 3, 1916, 6½ pp.

FIFTH NATIONAL SAFETY CONGRESS. Electric Railway Journal, vol. 48, no. 18, October 28, 1916, 4 pp.

CONVENTION OF THE BRIDGE AND BUILDING ASSOCIATION. Railway Review, vol. 59, no. 18, October 28, 1916, 2½ pp., illustrated.

CONVENTION OF THE TRAVELING ENGINEERS' ASSOCIATION. Railway Review, vol. 59, no. 18, October 28, 1916, 4¾ pp.

AMERICAN ASSOCIATION OF PASSENGER TRAFFIC OFFICERS. Railway Age Gazette, vol. 61, no. 17, October 27, 1916, ¾ p.

ANNUAL CONGRESS OF NATIONAL SAFETY COUNCIL. Railway Age Gazette, vol. 61, no. 17, October 27, 1916, 5½ pp.

BRIDGE AND BUILDING ASSOCIATION CONVENTION. Railway Age Gazette, vol. 61, no. 17, October 27, 1916, 8 pp.

THE TRAVELING ENGINEERS' ASSOCIATION. Twenty-fourth Annual Meeting, Chicago, Illinois, September 5th to 8th, 1916, 66½ pp., illustrated.

THE NATIONAL SAFETY CONGRESS. Railway Review, vol. 59, no. 17, October 21, 1916, 3⅓ pp., 2 figs.

THE AMERICAN ASSOCIATION OF REFRIGERATION HOLD SIXTH ANNUAL CONVENTION AT CHICAGO, OCTOBER 11, 12 AND 13—EXHIBIT A SPECIAL FEATURE. Refrigerating World, vol. 51, no. 4, October 1916, 4 pp.

NINTH ANNUAL CONVENTION A. R. E. E., OCTOBER 31-NOVEMBER 3, HOTEL LA SALLE, CHICAGO, COMMITTEE REPORTS. Railway Electrical Engineer, vol. 7, no. 17, October 1916, 28 pp., 7 figs.

SPECIAL INDEPENDENT OIL MEN'S ASSOCIATION CONVENTION REPORT. Oil, Paint and Drug Reporter, vol. 90, no. 20, October 30, 1916, 16 pp., illustrated.

PROCEEDINGS OF THE SEMI-ANNUAL MEETING, 1916, THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Journal of the American Society of Heating and Ventilating Engineers, vol. 23, no. 1, October 1916, 32 pp.

CRUSHING

SAVING ON SLAG THROUGH EFFICIENT CRUSHING, H. V. Schiefer. The Blast Furnace and Steel Plant, vol. 50, no. 11, November 1916, 4 pp., 6 figs.

BUILDS COAL BREAKER AND UNLOADER. The Iron Trade Review, vol. 59, no. 18, November 1, 1916, 1 p., illustrated.

DIES

DIE DESIGNS FOR PRODUCING SAME PIECES, G. T. Dubois. Steel and Iron, vol. 50, no. 10, October 1916, 1½ pp., 3 figs.

ABOUT DIE CASTINGS. Brass World and Platers' Guide, vol. 12, no. 10, October 1916, ¾ p.

THE HARDNESS DEPTH, PROPORTION AND FINISH IN DIES, Edward Dean. American Machinist, vol. 45, no. 18, November 2, 1916, 4¾ pp., 11 figs.

ELEVATORS AND CRANES

SELF-STARTING AND SELF-STOPPING ELEVATORS. Cassier's Engineering Monthly, vol. 50, no. 4, October 1916, 2 pp., illustrated.

TRACTIVE EFFORT OF OVERHEAD TRAVELLERS, G. H. Boot. Machinery (London), vol. 8, no. 211, October 12, 1916, 2 pp., 2 figs.

ENGINEERING MATERIALS

A SERIES OF TREATIES ON THE RARE METALS, TUNGSTEN, MOLYBDENUM, VANADIUM, URANIUM, Herman Fleck. Proceedings of the Colorado Scientific Society, vol. 11, October 1916, 73 pp.

THE RESISTANCE OF IRON AND STEEL TO COMPLÆTE REVERSALS OF STRESS, NOTES ON SOME RECENT EXPERIMENTS, W. C. Popplewell. The Engineering Review, vol. 30, no. 4, October 16, 1916, 2½ pp., 8 figs.

A STUDY OF THE SILICA REFRACTORIES, J. Spotts McDowell. Bulletin of the American Institute of Mining Engineers, no. 119, November 1916, 56½ pp., 31 figs.

GRAIN GROWTH PHENOMENA IN METALS, Zay Jeffries. Bulletin of the American Institute of Mining Engineers, no. 119, November 1916, 11 pp., 5 figs.

METALS IN STRUCTURAL ENGINEERING: THEIR WASTAGE BY CORROSION, W. H. Maxwell. Cassier's Engineering Monthly, vol. 50, no. 4, October 1916, 7 pp.

THE CHEMICAL AND PHYSICAL PROPERTIES OF FOUNDRY IRONS, J. E. Johnson, Jr. Metallurgical and Chemical Engineering, vol. 15, no. 9, November 1, 1916, 7 pp., 9 figs.

INSULUMINUM, TESTS OF A NEW METAL WITH HEAT RESISTING QUALITIES, Robert June. Practical Engineer, vol. 20, no. 21, November 1, 1916, 1¾ pp., 5 figs.

LE TRAITEMENT THERMIQUE DU BRONZE D'ALUMINUM À 10 O/O D'ALUMINUM, A. Portevin et G. Arnou. Revue de Métallurgie, vol. 13, no. 2, March-April 1916, 15 pp., 15 figs.
Heat treatment of aluminum bronze containing 10 per cent of aluminum.

SUR LA LIMITE ÉLASTIQUE DE L'ACIER, N. I. Belaiew et N. T. Goudtsow. Revue de Métallurgie, vol. 13, no. 2, March-April 1916, 33 pp., 37 figs.
Elastic limit of steel.

STUDIES REGARDING CONCRETE MIXTURES EMPLOYED IN CONSTRUCTION OF SHOAL LAKE AQUEDUCT, W. G. Chace and Douglas L. McLean. The Canadian Engineer, vol. 31, no. 17, October 26, 1916, 3½ pp.

NOTES ON THE INSPECTION OF BRONZE AND BRASS, Ernst Jonson. A paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio, 8½ pp.

RECENT PROGRESS IN METALLOGRAPHY, William Campbell. A paper to be presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio, 63 pp.

THERMAL REACTIONS OF CAST IRON, Thomas Turner. The Iron Trade Review, vol. 59, no. 16, October 19, 1916, 3 pp., 2 figs.

FOUNDRY

THE WORK OF THE ASSOCIATION OF MANUFACTURERS OF CHILLED CAR WHEELS, George W. Lyndon. Railway Age Gazette, vol. 61, no. 18, November 3, 1916, ½ p.

CASTING CAR WHEELS WITH MANGANESE TREADS, The Foundry, vol. 44, no. 291, November 1916, 4 pp., 11 figs.

FUELS AND FIRING

SPECIFIC GRAVITY STUDIES OF ILLINOIS COAL, Merle L. Nebel. University of Illinois Bulletin, vol. 13, no. 44, July 3, 1916, 45 pp., 9 figs.

GASFEUERUNGEN FÜR DAMPFKESSEL, Pradel. Zeitschrift für Dampfkessel und Maschinenbetrieb, vol. 39, no. 40, October 6, 1916, 2 pp., 5 figs.
Gas firing for steam boilers.

FIREBOX EFFICIENCY, J. T. Anthony. Railway Review, vol. 59, no. 18, October 28, 1916, 4 pp.

PULVERIZED COAL AS A METALLURGICAL FUEL, James Wheeler Fuller. The Blast Furnace and Steel Plant, vol. 50, no. 11, 5½ pp.

PULVERIZED COAL FOR OPEN HEARTHS, James Wheeler Fuller. The Iron Trade Review, vol. 59, no. 18, November 1, 1916, 5½ pp., 7 figs.

HYDRAULICS

MODULES AND UNIFORM DISCHARGE DEVICES FOR IRRIGATION AND WATERWORKS, Hugh Munro. The Journal of the Institution of Mechanical Engineers, no. 7, October 1916, 48½ pp., 33 figs.

MANITOBA HYDROMETRIC SURVEY. The Canadian Engineer, vol. 31, no. 17, October 26, 1916, 2½ pp., illustrated.

HYDRAULIC FORMULA RECONSTRUCTION, A. A. Barnes. Nature, vol. 98, no. 2449, October 5, 1916, ½ p.

EXPERIMENTS WITH SUBMERGED ORIFICES AND TUBES, T. C. Rogers and T. L. Smith. Engineering News, vol. 76, no. 18, November 2, 1916, 2 pp., 3 figs.

HYDRAULIC PACKING AT BALLARPUR COLLIERY, C. P., R. S. Davies. Transactions of the Mining and Geological Institute of India, vol. 10, no. 2, September 1916, 10 pp.

MASKINELLA UTRUSTNINGEN TILL TROLLHÄTTE KANALS SLUSSAR, Gösta v. Stapelmohr. Teknisk Tidskrift Mekanik, vol. 46, no. 90, October 1916, 6-12/ pp., 12 figs.
Mechanical equipment of the Trollhattan canal gates.

FLOW OF WATER OVER RIGHT-ANGLED V-NOTCH WEIR, Horace W. King. The Michigan Technic, vol. 29, no. 3, October 1916, 6½ pp.

INTERNAL COMBUSTION ENGINEERING

WISCONSIN OPPOSED PISTON DIESEL ENGINE. Motorship, vol. 1, no. 5, September 1916, 1 p., illustrated.

CRAIG-DIESEL ENGINES FOR U. S. SUBMARINES, T. Orchard Lisle. Motorship, vol. 1, no. 7, November 1916, 2 pp., 4 figs.

CALCULATIONS ON MARINE ENGINE DESIGN. The Practical Engineer, vol. 54, no. 1547, October 19, 1916, 1¼ pp., 2 figs.

MACHINE SHOP

GAUGING AND INSPECTION METHODS—I. Machinery (London), vol. 9, no. 213, October 26, 1916, 4½ pp., 4 figs.

MARKING CURVED SURFACES BY MACHINERY. Steel and Iron, vol. 50, no. 10, October 1916, 2¼ pp., 13 figs.

SPECIAL MACHINES FOR MAKING FUSE PARTS. Machinery (London), vol. 8, no. 211, October 12, 1916, 8 pp., 23 figs.

THE VICKERS SURFACE-HARDENING PROCESS. The Automobile Engineer, vol. 6, no. 95, October 1916, 1 p., illustrated.

CHROMIUM IN BALL BEARINGS. The Automobile Engineer, vol. 6, no. 95, October 1916, 1 p., 3 figs.

NOTES ON PISTON RING DESIGN, Gwilym Williams. The Automobile Engineer, vol. 6, no. 95, October 1916, 1½ pp., 3 figs.

NEW MACHINE FOR TESTING BOXES. Illustrated World, vol. 26, no. 3, November 1916, 1 p., illustrated.

GLOSSARY OF TERMS USED IN CONNECTION WITH THE CUTTING AND MEASURING OF SCREW THREADS. Greenfield Tap and Die Corporation, Catalog 37, 4 pp.

A GRAPHIC METHOD FOR CORRECTING STEEL TAPES, Walter Scott Weeks. Mining and Scientific Press, vol. 113, no. 18, October 28, 1916, 3 pp.

BUSHING ENGINE CYLINDERS. National Engineer, vol. 20, no. 11, November 1916, 1 1-3 pp., 3 figs.

SMALL SIZE COLD METAL SAWING MACHINE. The Iron Trade Review, vol. 59, no. 18, November 2, 1916, ½ p., illustrated.

PRESSING AND STAMPING METALS, Oberlin Smith. Industrial Management, vol. 52, no. 2, November 1916, 12 pp., 17 figs.

THE DEVELOPMENT OF IRREGULAR SHEET METAL PIPE CONNECTIONS. Marine Engineering of Canada, vol. 6, no. 10, October 1916, 1 4-5 pp., 3 figs.

MEASURING AND RECORDING INSTRUMENTS

INDICATORS—I, INTIMATE KNOWLEDGE OF THEIR OPERATION AND CONSTRUCTION OF VITAL IMPORTANCE TO POWER-PLANT ENGINEERS. Practical Engineer, vol. 20, no. 21, November 1, 1916, 3½ pp., 8 figs.

A NEW AUTOMATIC OXYGEN CARBON MONOXIDE AND CARBON DIOXIDE RECORDER. Metallurgical and Chemical Engineering, Vol. 15, no. 9, November 1, 1916, 1¾ pp., 4 figs.

MECHANICS

THE INFLUENCE OF SPEED ON ENDURANCE TESTS, W. C. Popplewell. The Engineer, vol. 122, no. 3173, October 20, 1916, 1 2-3 pp., 2 figs.

CONCERNING WORM GEARING, P. M. Heldt. The Horseless Age, vol. 38, no. 8, October 15, 1916, 3½ pp., 7 figs.

TOLMAN'S PRINCIPLE OF SIMILITUDE, P. W. Bridgman. The Physical Review, vol. 8, no. 4, October 1916, 8½ pp.

NOISE IN GEARING, AND SOME METHODS OF OVERCOMING IT, A. Fisher. Machinery (London), vol. 8, no. 211, October 12, 1916, 2½ pp., 3 figs.

THE LATERAL BENDING RESISTANCE OF METAL BOLTS AND LAG SCREWS IN WOOD, H. A. Thomas. The Rose technic, Rose Polytechnic Institute, vol. 26, no. 1, October 1916, 5 pp., 7 figs.

UEBER DEN WERT VON MODELLVERSUCHEN, H. Engels and H. Krey. Mitteilungen des K. K. Technischen Versuchsamtes, vol. 5, no. 3, 1916, 12½ pp.
Discussion of the value of tests on models

THE EFFICIENCY OF WORM-GEARS, Robert F. McKay. Mechanical World, vol. 60, no. 1556, October 27, 1916, 2-3 p., 3 figs.

PUMPS

MORE DATA ON TEST OF MONTREAL CENTRIFUGAL PUMP, A. Peterson. Engineering News, vol. 76, no. 18, November 2, 1916, 2 pp.

RAILROAD ENGINEERING

BRITISH EXPRESS LOCOMOTIVES, EXAMPLE OF HIGH SPEED PASSENGER ENGINES SHOWING THE TENDENCIES OF MODERN BRITISH PRACTICE, E. C. Poultney. Railway Mechanical Engineer, vol. 90, no. 11, November 1916, 6¾ pp., illustrated.

POWDERED COAL IN ENGINE SERVICE, C. W. Corning. Railway Mechanical Engineer, vol. 90, no. 11, November 1916, 2½ pp., illustrated.

INSTITUTION OF LOCOMOTIVE ENGINEERS. The Railway Gazette, vol. 25, no. 15, October 13, 1916, 1½ pp.

DETERMINING CAR ACCELERATION, P. M. Heldt. The Horseless Age, vol. 38, no. 8, October 15, 1916, 3 pp., illustrated.

LOCOMOTIVE FUEL ECONOMY AND BOILER DESIGN, J. T. Anthony. Railway Age Gazette, vol. 61, no. 16, October 20, 1916, 5 pp., 6 figs.

THE YOUNG LOCOMOTIVE VALVE GEAR. Railway and Locomotive Engineering, vol. 29, no. 11, November 1916, 2 1-3 pp., 6 figs.

PEAT POWDER AS LOCOMOTIVE FUEL. Engineering, vol. 102, no. 2651, October 20, 1916, 4-5 p.

RULES AND INSTRUCTIONS GOVERNING THE APPLICATION OF COUNTERBALANCE TO LOCOMOTIVES, Southern Pacific Co. Railway Review, vol. 59, no. 19, November 4, 1916, 1½ pp., 2 figs.

FUEL ECONOMY AND PROPER DRAFTING OF LOCOMOTIVES, D. R. MacBain. Central Railway Club, advance copy of paper presented at regular meeting on November 10, 1916, 17 pp., 10 figs.

REFRIGERATION

THE KAPADIA SYSTEM, SOME RESULTS OF REFRIGERATING TESTS. Cold Storage, vol. 19, no. 223, October 19, 1916, 1¾ pp., illustrated.

REFRIGERATION IN TRANSIT, M. E. Pennington. Railway Review, vol. 59, no. 19, November 4, 1916, 2¼ pp., 6 figs.

A STUDY OF HEAT TRANSFER SHOWING THE IMPOSSIBILITY OF ARRIVING AT A FIGURE WHICH WILL DO FOR ALL CONDITIONS AND ARRANGEMENTS, A. G. Solomon. Refrigerating World, vol. 51, no. 4, October 1916, 1½ pp.

SHOP MANAGEMENT

THE ECONOMICS OF MATERIAL HANDLING IN MANUFACTURING PLANTS, Reginald Trautschold. Industrial Management, vol. 52, no. 2, November 1916, 18 pp., 25 figs.

WORKS ORGANIZATION, A. D. C. Parsons, Edwin L. Orde and G. H. Tweddell. North-East Coast Institution of Engineers and Shipbuilders, advance proof of paper to be read at a General Meeting of the Institution, 28 pp., 10 figs.

STEAM ENGINEERING

POWER AND STEAM TESTS AT CENTRAL FLORIDA, E. W. Kerr. Sugar, vol. 18, no. 9, September 1916, 2½ pp., illustrated.

WESTINGHOUSE GEARED TURBINE DRIVE. Shipping Illustrated, vol. 57, no. 730, October 28, 1916, 3 pp.

AURORA, ELGIN & CHICAGO R. R. POWER STATION. Practical Engineer, vol. 20, no. 21, November 1, 1916, 5¼ pp., 7 figs.

SCIENTIFIC MANAGEMENT OF A BOILER ROOM, H. H. Bailey. Proceedings of the Engineering Association of the South, vol. 27, no. 3, July, August, September 1916, 7¼ pp.

BOILER SETTINGS FOR SMOKELESS COMBUSTION, Osborn Monnett. Southern Engineer, vol. 26, no. 3, November 1916, 3½ pp., 11 figs.

VALUATION

GROWTH AND DEPRECIATION, Julian Loebenstein. Proceedings of the American Institute of Electrical Engineers, vol. 35, no. 11, November 1916, 18½ pp., illustrated.

CONTINUOUS INVENTORIES: THEIR PREPARATION AND VALUE, Harry E. Carver. Proceedings of the American Institute of Electrical Engineers, vol. 35, no. 11, November 1916, 12½ pp.

THE EFFECT OF RECENT DECISIONS ON THE WORK OF INVENTORY AND APPRAISAL, Philander Betts. Proceedings of the American Institute of Electrical Engineers, vol. 35, no. 11, November 1916, 6 pp.

OBSOLESCENCE IN APPRAISALS FOR RATE MAKING, C. C. Harshman. Engineering News, vol. 76, no. 18, November 2, 1916, 1½ pp.

VARIA

A SERVICEABLE OILING SYSTEM, G. H. Kimball. Practical Engineer, vol. 20, no. 19, October 1, 1916, 2 pp., 3 figs.

DEVELOPMENT OF ENGINEERING SHOP COURSES AT WISCONSIN, A. L. Goddard. The Wisconsin Engineer, vol. 21, no. 1, October 1916, 8½ pp., illustrated.

ECONOMICS EFFECTED BY WASHED STACK GAS, Charles C. Lynde. The Blast Furnace and Steel Plant, vol. 50, no. 10, October 1916, 5 pp., 5 figs.

MODERN STEAM LAUNDRY MACHINERY. The Engineer, vol. 122, no. 3173, October 20, 1916, 1 1-3 pp., 5 figs.

MOTION AND RELATIVE POSITIONS OF PROJECTILES IN FLIGHT. Canadian Machinery and Manufacturing News, vol. 16, no. 12, September 21, 1916, 1⅓ pp., 3 figs.

PRODUCTION OF DIES AND MARKING DEVICES, Charles C. Lynde. Steel and Iron, vol. 50, no. 9, September 1916, 4 pp., 8 figs.

REMARKABLE BRITISH ADMISSIONS IN RE FOREIGN VS. AMERICAN PIPE. Mill Supplies, vol. 6, no. 10, October 1916, 2¾ pp.

THE EXTENSION OF WOMEN'S EMPLOYMENT DURING THE WAR. The Railway News, vol. 106, no. 2755, October 21, 1916, ½ p.

THE CO-OPERATIVE EFFORT IN INDUSTRY. Machinery (London), vol. 8, no. 211, October 12, 1916, ½ p.

THE NATIONAL PHYSICAL LABORATORY—ITS WORK AND AIMS, Walter Rosenhain. The Journal of the West of Scotland Iron and Steel Institute, vol. 23, no. 6, April 1916, 49 pp., 32 figs.

THE LIFE AND WORK OF WILBUR WRIGHT, Griffith Brewer. The Aeronautical Journal, vol. 20, no. 79, July-September 1916, 15½ pp., 17 figs.

MAKING BLAST FURNACE WORK SAFE—I, Frederick H. Fillcox. The Iron Trade Review, vol. 59, no. 16, October 19, 1916, 5¼ pp., 7 figs.

WHAT CAN BEST BE DONE TO ADVANCE THE INTERESTS OF THE ENGINEERING PROFESSION IN THE UNITED STATES, J. A. L. Waddell. Proceedings of The Engineers' Society of Western Pennsylvania, vol. 32, no. 6, July 1916, 97½ pp.

CHARTS

BEARING LOADS OF HELICAL BEVEL GEARS. The Horseless Age, vol. 38, no. 8, October 15, 1916.

A GRAPHIC METHOD FOR CORRECTING STEEL TAPES, Walter Scott Weeks. Mining and Scientific Press, vol. 113, no. 18, October 28, 1916.

Tape Correction Chart: Correcting for Sag, Stretch and Temperature on any Slope, and for any length of Tape, when Pull = 2000 × wt. of 1 ft. of tape.

Chart showing effect of rate of combustion on efficiency of arch, efficiency of boiler and heat losses. Committee Reports and Subjects for Discussion. The Traveling Engineers' Association. Twenty-fourth Annual Meeting, Chicago, Ill., September 5th to 8th, 1916.

CONVEYING COAL THROUGH PIPES

(Bibliographical notice compiled in the Library of the United Engineering Society)

DARLEY SUCTION CONVEYOR FOR COAL AND ASHES. Iron Age, vol. 85, pp. 1132-1135, 1910.
Boston Elevated Ry. installation. Illustrated description of pipe conveyor for coal.

PNEUMATIC ASH ELEVATOR AND CONVEYOR. Compressed Air Mag., vol. 15, p. 5659, 1910.
Illustrated description of apparatus made by Darley Engineering Co., N. Y.

PNEUMATIC TRANSPORTATION OF COAL, M. Buhle. Glückauf, vol. 49, pp. 1945-6, 1913. Compressed Air Mag., vol. 19, pp. 7119, 1914.
Details of a German plant using a pipe line and compressed air for transporting coal.

CONVEYING COAL BY SUCTION. Zeit. Ver. deut. Ing., vol. 57, pp. 474-76, 1913.
An illustrated article showing apparatus for conveying coal through pipes by suction.

ASH AND COAL HANDLING EQUIPMENT, H. J. Edsall. Coal Age, 1913, vol. 4, p. 78.
Center of article describes pneumatic system for handling ashes and coal with remarks on cautions to be observed. No illustration.

TRANSPORTING COAL THROUGH PIPE LINES. Power, vol. 38, p. 447, 1913. Coal Age, vol. 4, p. 307, 1913.
A short account of a proposed method of conveying coal through pipes with water pressure. No technical details.

RAILLESS COAL TRANSPORTATION. Coal Age, vol. 3, p. 342, 1913.
Does not consider pipe method seriously, but makes detrimental comments on its feasibility.

PNEUMATIC CONVEYING OF BROWN COAL, Schorrig. Braunkohle, vol. 12, pp. 447-51, 1913.
Description of a plant for conveying coal in pipes.

PNEUMATIC CONVEYING OF COAL, Schröder. Braunkohle, pp. 684-86, 1913.
General description of coal conveying apparatus. No diagrams.

COAL AND ASH HANDLING AT PIERCE ARROW PLANT. Power, vol. 39, pp. 40-43, 1914.
Description and illustrations of apparatus. The coal and ashes are conveyed by suction.

PNEUMATIC COAL TRANSPORTER, E. Koenigs. Engin. Mag., vol. 48, pp. 438-40, 1914.
Description of an apparatus for conveying small coal from bunker to boiler; illustrated.

A NEW METHOD FOR TRANSPORTING SMALL COAL, E. Koenigs. Proc. South Wales Inst. of Engrs., vol. 30, pp. 469-88, 1915. Compressed Air Mag., vol. 20, pp. 7478-9, 1915.
A very good article with illustrations and plans. Considers pneumatic transportation through pipes, and is the most complete article found.

PNEUMATIC CONVEYING OF GRAIN, M. Buhle. Zeit. d. Ver. deut. Ing., vol. 42, p. 921, 1898.

PNEUMATIC GRAIN ELEVATORS, M. Buhle. Zeit. d. Ver. deut. Ing., vol. 53, p. 354, 1909.
Principles possibly applicable to coal handling. Make use of pipes.

SUCTION GRAIN CONVEYOR, ETC., M. Buhle. Zeit. d. Ver. deut. Ing., vol. 57, p. 362, 1913.
Description and cuts of grain conveyor. Principles applicable to coal conveying.

Professional and Educational Directory

1. Consulting Engineers ..... Page 2
2. Engineering Colleges ..... Page 4

CONSULTING ENGINEERS

GEOGRAPHICAL INDEX

California
Morrin, Thomas

Connecticut
Harris, Harry E.

Washington, D. C.
Tait, Godfrey M. S.

Illinois
Arnold Co.
Austin, William A.
Doud, Willard
Jackson, D. C. & Wm. B.
Massey Co., Geo. B.
Yeomans, Lucien I.

Massachusetts
Gooding, Charles S.
Green Co., Samuel M
Main, Chas. T.
Norton, Fred E.
Stevens, John A.
Stone & Webster

Maryland
Varney, William W.

Minnesota
Rollins, Len E.

New Jersey
Conard, William R.
Krause, Arthur E.
Prince, Walter F.

New York
Cary, Albert A.
Collins, Hubert E.
Colwell, James V. V.
Cornwall & Raymo, Inc.
Electrical Testing Laboratories, Inc.
Hannah, Frederick A.
Hooper-Falkenau Engineering Co.
Kidder, W. M.
Marble, H. M.
Parsons, W. Everett
Polakov, Walter N.
Reeve, Sidney A.
Slade, Arthur J.
Smerling, Carl
Testing Laboratory of The Automobile Club of America
Vickess, Samuel
Wayte, Inc., W. J.

Ohio
Guthrie, James
Kelly, Thos. C.
Weston, Burt H.

Pennsylvania
Akimoff, N. W.
Day & Zimmermann
Francis, Isaac Hathaway
Jellett Co., Stewart A.

New Hampshire
Abbott, Jr., W. G.
Manning, Chas. H.

Rhode Island
Gilbreth, Frank B.

W. G. ABBOTT, Jr.
Research Engineer
Development of Inventions, Special Machinery and Industrial Processes, Chemical and Electrical.
Laboratory: WILTON, N. H.

HUBERT E. COLLINS
Member A.S.M.E.
Consulting Engineer
Power Plant
Design—Construction—Operation
Specialist on power plant operation. Diagnostician on power plant troubles. Investigations and reports for manufacturers, corporations, and other consultants desiring the added opinion of practical experience.
132 Boyce Ave., UTICA, N. Y.

WILLARD DOUD
Member A.S.M.E.
Mechanical—Electrical ENGINEER
Railroad Shops, Factories, Power Plants
410-5 Old Colony Bldg., CHICAGO

N. W. AKIMOFF, M. E.
(Originator of the Dynamic Balancing Machine)
Special Research Work. Mathematics of Engineering. Vibrations
Harrison Bldg., Philadelphia

JAMES V. V. COLWELL
Member A. S. M. E.
Equipment Engineer
Inspection—Appraisals—Management
Logical mechanical arrangement of equipment for economical production
105 West 40th Street, NEW YORK, N. Y.

ELECTRICAL TESTING LABORATORIES
Electrical and Mechanical Laboratories
Tests of Electrical Machinery, Apparatus and Supplies. Materials of Construction, Coal, Paper, etc. Inspection of Material and Apparatus at Manufactories.
80th St. & East End Ave., N.Y. CITY

THE ARNOLD COMPANY
Engineers—Constructors
Electrical—Civil—Mechanical
105 So. La Salle Street, CHICAGO
111 Broadway, NEW YORK

WILLIAM R. CONARD
Assoc. Mem. A.S.M.E.
Assoc. Mem. A.S.C.E.
Inspecting Engineer
BURLINGTON, N. J.

ISAAC HATHAWAY FRANCIS
Member A.S.M.E.
Consulting Engineer
1508 Commonwealth Trust Bldg.
PHILADELPHIA, PA.
Power, Heating, Ventilating
Electrical and Sanitary Engineering

WILLIAM A. AUSTIN
Member A. S. M. E.
Consulting Engineer
Specialist in Motive Power and Railway Equipment
ANALYSIS—DESIGN—INSPECTION
1642 McCormick Bldg., CHICAGO

CORNWALL & RAYMO, Inc.
Consulting Engineers
AND
Designers and Builders of Machinery
Specialize in Machines for use in all Methods of Printing and Allied Trades.
52 Duane St., NEW YORK CITY

FRANK B. GILBRETH
(Incorporated)
Consulting Engineers
Management
Motion Study Waste Elimination
Reports
77 Brown St., PROVIDENCE, R. I.

ALBERT A. CARY
Member A.S.M.E.
Designs, Tests or Specifications for Equipment of
Power Plants, Mills or Business Buildings
Furnace Designs & Fuel Economies
95 Liberty Street, NEW YORK

DAY & ZIMMERMANN
Engineers
Industrial Plants
Public Utilities
611 Chestnut St., PHILADELPHIA

CHARLES S. GOODING
Tech. Graduate
Member A.S.M.E.
Machinery Designing
Patent Attorney and Expert
27 School Street, BOSTON, MASS.

The rate for insertion of cards in Professional and Educational Directory is $2.00 per month.

CONSULTING ENGINEERS

SAMUEL M. GREEN COMPANY
Engineers—Architects
Appraisers
293 Bridge St., SPRINGFIELD, MASS.

THOS. C. KELLY
Member A.S.M.E.
Consulting Engineer
405 2nd Natl. Bank Bldg.
CINCINNATI, O.

FRED E. NORTON
Consulting Engineer
Power Plant
Design—Construction—Operation
656 Main St., WORCESTER, MASS.

JAMES GUTHRIE
Consulting Engineer
MOTOR VEHICLES and GAS ENGINES
Erie Bldg., CLEVELAND

WALTER M. KIDDER
Consulting and Production Engineer
Factory Organization
Costs, Efficiency and Control
Enhancing Production
143 W. 82nd St., NEW YORK

W. EVERETT PARSONS
Member A.S.M.E. and A.S.R.E.
Consulting Engineer
Refrigeration—Ice Making
Power Plants
50 Church St. NEW YORK

FREDERICK A. HANNAH
Member A.S.M.E.
Consulting Engineer
Organization and Management
40 Wall St., NEW YORK

ARTHUR E. KRAUSE
Member A.S.M.E.
Purifying and Clarifying Oily and Emulsified Condensate
The only efficient and non-chemical filtration process for condensate returns
345 Fairmount Ave., JERSEY CITY

WALTER N. POLAKOV
Member A.S.M.E.
Consulting Engineer
For Management Problems of Central Stations and Industrial Power Plants
Tests, Investigations, Reports, Records and Cost Systems.
31 Nassau St. NEW YORK

HARRY E. HARRIS
Member A.S.M.E.
Manufacturing Engineer
Planning, Designing and Installing, Manufacturing Processes, Tools, Equipment, Machinery for Interchangeable, Low Cost, High Grade Products.
BRIDGEPORT, CONN.

CHAS. T. MAIN
Member A.S.M.E.
Mill Engineer and Architect
201 Devonshire St., BOSTON, MASS.

WALTER F. PRINCE
Foundry Consulting Engineer
ELIZABETH, N. J.

FREDERICK E. HEALY
Member A.S.M.E.
Shell Plant Doctor
Forging, Heat-Treating and Machining Plants.
British, French and Russian Shells.
1387 Queen St., W., TORONTO, CANADA

CHAS. H. MANNING
Member A.S.M.E.
CHAS. B. MANNING
Consulting Engineers
886 Elm St., MANCHESTER, N. H.

SIDNEY A. REEVE
Litigation—Special Problems
STEAM—HYDRAULICS
PNEUMATICS—MECHANICS
120 Broadway, NEW YORK

HOOPER-FALKENAU ENGINEERING CO.
Industrial Engineers
and Architects
Woolworth Bldg., NEW YORK CITY

H. M. MARBLE
141 Broadway
NEW YORK
PATENTS

FREDERICK BASS, C.E.
LEN E. ROLLINS, M.E.
Jun. Mem. A.S.M.E.
Engineers for Public Works, Buildings, and Building Equipment
224 Plymouth Bldg., MINNEAPOLIS, MINN.

D. C. & WM. B. JACKSON
Consulting Engineers for
Electric and Allied Properties
CHICAGO Harris Trust Bldg.
BOSTON 248 Boylston St.

GEO. B. MASSEY COMPANY
Consulting Engineers
EXCAVATION
Equipment and Methods
Peoples Gas Bldg., CHICAGO

ARTHUR J. SLADE
Member A.S.M.E. Member S.A.E.
Assoc. A.I.E.E.
Consulting Engineer
Specialist in
Design, Construction and Operation of mechanically propelled road vehicles
Times Building, NEW YORK

STEWART A. JELLETT CO.
Building Equipment Engineers
Steam Power Plants. Heating and Ventilation
Electric Lighting and Power
Sprinkler Equipments
Elevators and Refrigeration
Real Estate Trust Bldg. PHILADELPHIA

THOMAS MORRIN
Member A.S.M.E. Member A.S.H. & V.E.
Member I.H. & V.E. of Great Britain
Efficiency Reports, Investigations, Commercial Tests, Power Plants, Light, Heat, Sanitary, Water and Mechanical Equipment of Buildings, Mines, Mills, Ventilation, etc.
Phelan Building, SAN FRANCISCO

CARL SMERLING
Consulting Engineer
Furnace Design Fuel Combustion
Patent Huber Hand Stoker, guarantee large fuel saving at low expense. No fires to clean or slice, doors closed. 100% on the investment and burn bituminous coal meeting requirements of any city.
Park Row Bldg., NEW YORK CITY

The rate for insertion of cards in Professional and Educational Directory is $2.00 per month.

CONSULTING ENGINEERS

JOHN A. STEVENS, ENGINEER
Member A.S.M.E.
Light, Heat and Power Problems
Power Plants
Analysis—Design—Construction
8 Merrimack St., LOWELL, MASS.

THE TESTING LABORATORY
of The Automobile Club of America
54th and 55th Sts., West of Broadway
NEW YORK CITY
Every facility for making thorough and unbiased tests of motors, carburetors, and accessories for
AUTOMOBILES AEROPLANES BOATS

W. J. Wayte D. J. Lewis, Jr.
W. J. WAYTE, Inc.
Chemical and Mechanical Engineers
Utilization of Wastes in Power and Manufacturing Plants.
One Liberty St. NEW YORK

STONE & WEBSTER
147 Milk Street
BOSTON, MASS.

WILLIAM W. VARNEY
Member A. S. M. E.
Attorney at Law and Patent Solicitor
PATENTS COPYRIGHTS TRADE-MARKS
Twenty years practice before the United States Patent Office.
1221 Calvert Bldg., BALTIMORE, MD.

BURT H. WESTON
Assoc. Mem. A. S. M. E.
Consulting and Equipment Engineer
Complete design and equipment of Power Plants, Mills and Factories.
402 Commercial Bldg., DAYTON, OHIO

GODFREY M. S. TAIT
Member A.S.M.E.
Consulting Engineer
Power and Heating Plants
Electric Light and Pumping Stations
Accurate Combustion of all Fuels
1413 G St., N.W., WASHINGTON, D.C.

SAMUEL VICKESS
Member A.S.M.E.
Consulting Engineer
Expert in Sugar Factories and Estates
129 Front St., NEW YORK

LUCIEN I. YEOMANS
Industrial Engineer
CHICAGO

ENGINEERING COLLEGES

GEOGRAPHICAL INDEX

Illinois
Northwestern University

Indiana
University of Notre Dame

Louisiana
Louisiana State University

Massachusetts
Worcester Polytechnic Institute

New Jersey
Rutgers College

New York
New York University
Polytechnic Institute of Brooklyn
Rensselaer Polytechnic Institute

Ohio
Case School of Applied Science
Ohio State University

Pennsylvania
Lafayette College

Rhode Island
Rhode Island State College

Virginia
Virginia Polytechnic Institute

CASE SCHOOL OF APPLIED SCIENCE
CLEVELAND, OHIO
Courses in Civil, Mechanical, Electrical Mining, Metallurgical, and Chemical Engineering and in Physics. Half of each day given to practical work in the field, the shop, or the laboratory. Send for catalogue.

NEW YORK UNIVERSITY SCHOOL OF APPLIED SCIENCE
Departments of Civil, Mechanical, Chemical and Industrial Engineering.
For announcements or information, address: CHARLES HENRY SNOW, *Dean*, University Heights, Bronx, N. Y. City.

POLYTECHNIC INSTITUTE OF BROOKLYN
Course in Mechanical Engineering, Evening Post-Graduate Courses. Fred. W. Atkinson, Ph.D., President; W. D. Ennis, Member A.S.M.E., Professor Mechanical Engineering.

LAFAYETTE COLLEGE
EASTON, PA.
On the Delaware River, two hours from New York or Philadelphia.
Department of Civil, Mechanical, Electrical and Chemical Engineering. Cooperative Shop courses in the foundries and manufacturing plants of the Lehigh Valley.
Address the Registrar

NORTHWESTERN UNIVERSITY
COLLEGE OF ENGINEERING
Five years of thorough professional training in Mechanical and Electrical Engineering or in Civil Engineering.
Small classes.
For information, address JOHN F. HAYFORD, Director, Evanston, Illinois.

THE RENSSELAER POLYTECHNIC INSTITUTE
Courses in Civil, Mechanical, Electrical and Chemical Engineering and General Science leading to the degrees C.E., M.E., E.E., Ch.E. and B.S. Also graduate and special courses.
Unsurpassed laboratories.
Catalogue sent upon application.
TROY, N. Y.

LOUISIANA STATE UNIVERSITY
Baton Rouge, La.
Courses in Civil, Mechanical, Electrical, Chemical and Sugar Engineering. Degrees—B.S., C.E., M.E., E.E. and Ch.E.
Well equipped laboratories and shops. Tuition free to citizens of the United States.

OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING
Architecture—Engineering—Applied Science
Eight courses leading to degrees, and various short industrial and special courses. Large faculty and equipment of first order.
For information apply to Entrance Board, Ohio State University, Columbus, Ohio.

RHODE ISLAND STATE COLLEGE
Department of Mechanical, Civil, Electrical and Chemical Engineering; courses leading to the degree of B.S. in the respective lines of engineering.
Address: Rhode Island State College
KINGSTON, R. I.

The rate for insertion of cards in Professional and Educational Directory is $2.00 per month.

ENGINEERING COLLEGES

RUTGERS COLLEGE

Courses in Civil, Electrical and Mechanical Engineering, Chemistry, Ceramics, Agriculture, Biology and General Science. For catalogue and other information address, Luther H. Martin, Registrar.

NEW BRUNSWICK, N. J.

VIRGINIA POLYTECHNIC INSTITUTE
Blacksburg, Va.

Courses in Applied Science, Agriculture, Civil, Mechanical, Electrical, Mining, Chemical Engineering. Laboratory equipment. Apply to Registrar for Catalogue.

J. D. EGGLESTON, President.

COLLEGE OF ENGINEERING
UNIVERSITY OF NOTRE DAME
Notre Dame, Indiana

Four year Courses in Civil, Electrical, Mechanical, Chemical, Mining Engineering leading to degrees. Two year courses in Electrical and Mechanical Engineering leading to certificate. Write for catalogue.

WORCESTER POLYTECHNIC INSTITUTE

Courses in Mechanical, Civil and Electrical Engineering, in Chemistry and in General Science. Graduate instruction in all departments.

For information, address Ira N. Hollis, President, Worcester, Mass.

The rate for insertion of announcements of Engineering Colleges is $2.00 per month. Orders are accepted on a "till forbid" basis, subject to cancellation at any time by giving thirty days' notice.

Nine Thousand Cards

printed and distributed for you among your potential clients at a cost of only two dollars.

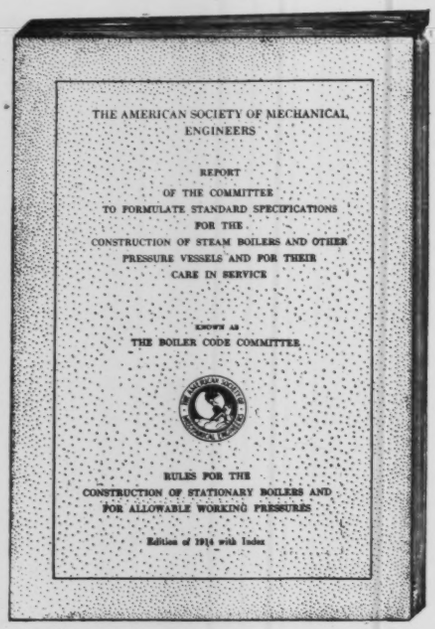
This is substantially the service you will receive each month, by arranging for insertion of your Professional Card in The Journal of The American Society of Mechanical Engineers.

Monthly edition of The Journal, 9000 copies. Rate for Professional Cards, $2.00 per insertion. Orders accepted on open basis, subject to discontinuance at any time on due notice.

See Pages Immediately Preceding

The rate for insertion of cards in Professional and Educational Directory is $2.00 per month.

The Boiler Code



Received by the Council of the Society, February, 1915 and ordered printed. 11,000 copies published to date.

Recently Reprinted with Complete and Sectional Indexes.

One hundred and forty-seven pages, including appendix and indexes.

Thirty illustrations. 8vo.

Prices

$0.40 to members
.80 to non-members

A signal event for the boiler industry and one that means much to the field of power production in general was the completion of the Am. Soc. M. E. Boiler Code. This report, containing standard specifications for the construction, equipment and use of steam boilers, embodies the collective knowledge of the world's best experts. Its issuance by the Society marks a new era in the manufacture of steam boilers and inaugurates a movement of great importance for the protection of human life and property.

For the engineer, designer and student, the Boiler Code is invaluable as a treatise, covering the modern design and methods of construction of steam boilers and rules for determining the allowable working pressures for boilers in operation. It is used in many of our leading universities as a boiler text book.

The construction rules are divided in two parts, one for new installations and the other for existing installations, and following this is an appendix in which are placed examples, illustrations, references, and data that are in nature supplementary. The rules for existing installations (Part I) cover all details of construction of new steam boilers and the regulations for allowable working pressures upon them, the details being referred to in the following order: Materials of construction, including the material specifications; maximum allowable working pressures; boiler joints, braced and stayed surfaces; combustion chambers; tubes; riveting and calking; manholes and handholes; safety valves; water and steam guages; and fittings and appliances. At the end of Part I is a section devoted to heating boilers, in which the above order of subjects is also adhered to. In Part II, which is devoted to existing installations, the same order of subjects is followed, although less complete and exacting in details.

The U. S. Government now specifies that boilers in use at the Canal Zone are to be in accordance with the Am. Soc. M. E. Boiler Code. The Republic of Argentina, So. America specifies all its boilers made to the Code. It is operative as a legal construction code in the states of Wisconsin, Indiana, Ohio, Pennsylvania and California. The Code has also been adopted as a standard by the Industrial Commission of Pennsylvania, by fifteen of the leading boiler insurance companies, leading boiler manufacturers, and by many of our foremost consulting engineers.

The American Society of Mechanical Engineers

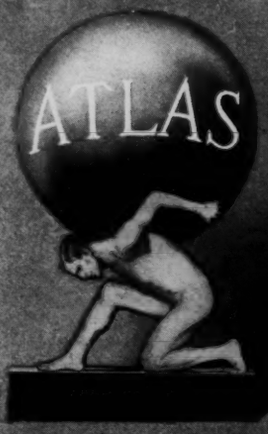
29 West 39th Street, New York

ADVERTISING SECTION

1. Display Advertisements - Page 8

2. Classified List of Mechanical Equipment - - - - Page 50

3. Alphabetical List of Advertisers - - - - Page 64



ATLAS STEEL BALLS

Accuracy, uniformity and quality are the essential features for which every ball manufacturer strives.

Nowhere in the world will you find a ball that so nearly embodies every one of these essentials as the Atlas. This has been proved to the satisfaction of the best engineers in every line of industry in this country and we are always ready to demonstrate it.

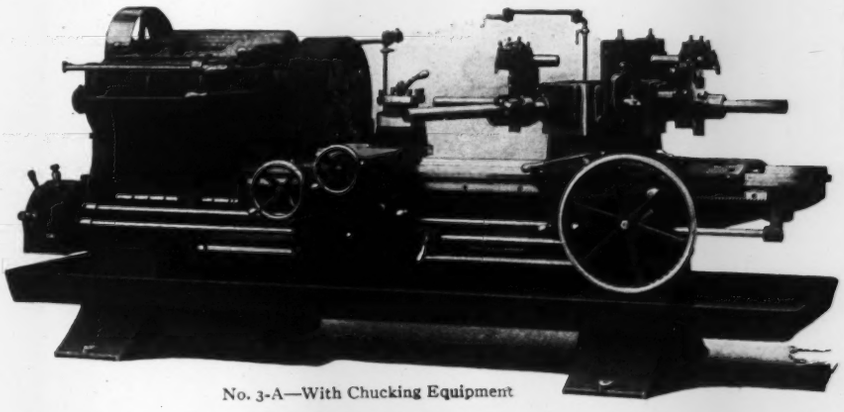
The Atlas trade-mark—easy to remember and easy to get—is positive assurance of the very highest steel ball quality.

ATLAS BALL COMPANY
Glenwood Avenue at Fourth Street
Philadelphia, U. S. A.

Maximum Accuracy: Maximum Production

TWO SIZES
No. 2-A—Bar work 2½" x 29"
castings and forgings 12"
No. 3-A—Bar work 3½" x 40"
castings and forgings 16"

Universal Hollow-Hexagon Turret Lathes



No. 3-A—With Chucking Equipment

THE extreme rigidity and great reserve power of the Universal Hollow-Hexagon Turret Lathes permit very high speeds or very deep cuts without impairing the accuracy of the work.

And these machines are so quickly adjusted, so easily operated, that they are economical even on many short-run jobs that were formerly produced only on engine lathes.

In brief, they are profitable producers on long or short runs.

THE WARNER & SWASEY COMPANY

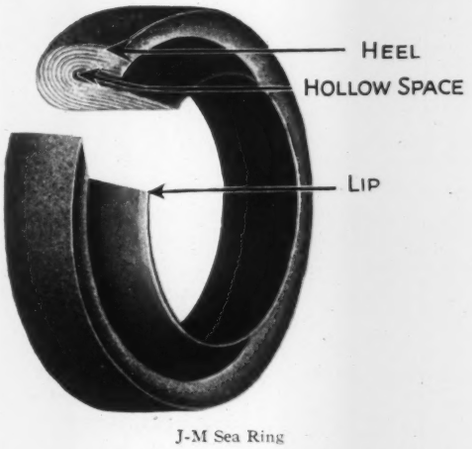
Works and Main Office: CLEVELAND

Branch Offices: NEW YORK BOSTON BUFFALO DETROIT and CHICAGO

See Our Suite 1916 A. S. M. E. Condensed Catalogues of Mechanical Equipment

UNIVERSAL HOLLOW-HEXAGON TURRET LATHES *TURRET SCREW MACHINES* *BRASS-WORKING MACHINES*

J-M Sea Rings reseat themselves at every pressure change—they don't score the rod



J-M Sea Ring

It is practically impossible to pack a rod tight with inert packing and have it exert an equal pressure all around. Some one point of hardness or stiffness will produce more than its share of the friction and it's here that the packing wears first but not before it has left its mark in the rod.

Sea Rings won't do this because they ease up their hold at least once every stroke and each time the pliable lip is forced against the rod, it reseats itself.

If there is any wear on the rod it is evenly distributed all around.

Replacing scored rods is about the best proof of the proverb—an ounce of prevention is worth a pound of cure. J-M Sea Rings save the cure. Try them. For steam, air or liquid.

H. W. Johns-Manville Co.

Executive Offices: 296 Madison Avenue, New York City

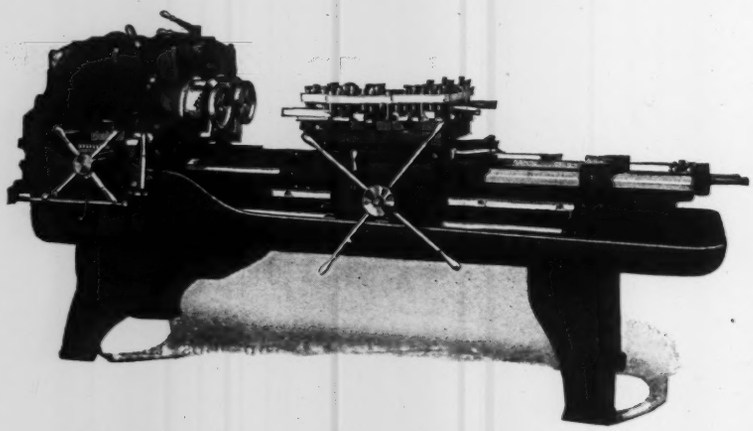
Branches in All Large Cities

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

See Our Suite 1916 A. S. M. E. Condensed Catalogues of Mechanical Equipment

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

HIGH PRODUCTION MACHINES



Hartness Double Spindle Flat Turret Lathe for Chucking Work

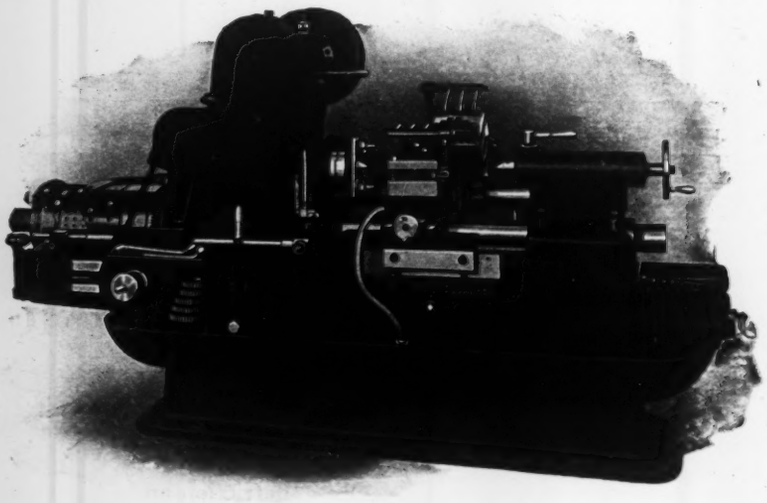
Two spindles, two sets of tools, two pieces of work. One turret, one cycle of operations, one operator. Practically double the output at about the same expense.

Introduced ten years ago, and now the leading machine in the automobile field, and in similar lines where chuck work comes in large lots.

WORKING RANGE. Swing when both spindles are used is 10 inches. Cross travel of head is 10½ inches. Hole through spindle is 3⅛ inches.

Or it may be used as a single spindle machine, with a large chuck on the rear spindle, when it swings 17 inches.

The Fay Automatic Lathe



An automatic machine for work held on centers, or carried on arbors. Particularly adapted to second operation work.

RANGE OF WORK. It swings 14 inches over the shears and 10 inches over the carriage. It will turn up to 10 inches in length, and takes 18 inches between the centers. The movements are entirely automatic, the machine stopping itself when the work is completed.

FEEDS. The movements of the various tools are controlled by adjustable cams. The cam-shaft has an adjustable quick drive for idle motions, and a slow drive through change gears for feeding.

CARRIAGE. The Carriage, attached to the central shaft, has lateral motion obtained from cams on the drum. Movement in the vertical plane is given by removable formers, mounted on former slide and operated from the drum. These two movements may be made either separately or in conjunction.

BACK TOOL ARMS. The back tool holder is adjustable on the rear shaft and has a lateral motion controlled by the cam drum. Movement in the vertical plane is obtained from a separate sliding cam. These movements may also be made separately or in conjunction.

TAPER TURNING is effected by adjustment of the straight former on the former slide operating the carriage; for steep tapers, such as the faces of bevel gears, etc., a special bevel attachment is provided, controlling the back tool arm.

FORM TURNING in wide variety is also effected by formers operating the carriage. This is especially useful in crowning cone pulleys, etc.

JONES & LAMSON

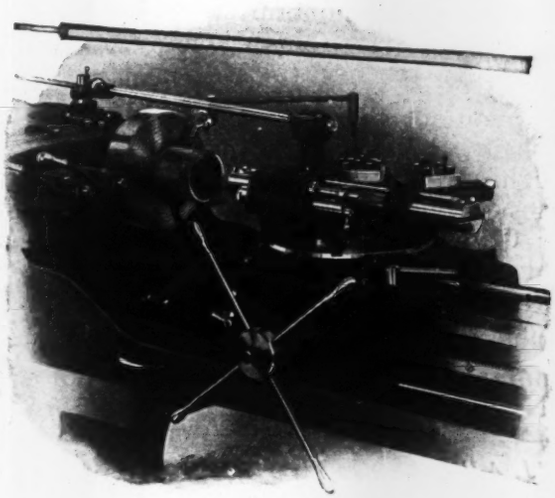
SPRINGFIELD,

97 Queen Victoria

Germany, Holland, Switzerland, Austria-Hungary: M. Koyemann, Charlottenstrasse 112

UNIQUE EQUIPMENT FOR THREADING

Automatic Chasing Attachment



The Hartness Chasing Attachment is shown applied to the Flat Turret Lathe.

This attachment is automatic. The carriage is locked to the bed and the attachment clutched with its positive drive from the work spindle. The threading tool feeds forward at cutting depth under lead screw control until the tool bar strikes a stop. The tool is then withdrawn to clear the work and returned at high speed to the starting point, where it is again fed in to cutting depth and engaged with the lead screw. The work spindle revolves continuously. The only motion required of the operator is that of adjusting the cross sliding head forward a slight amount during the return of the cutter to feed the tool in for the new cut. There is no possibility of overrunning and gouging into a shoulder, no matter how fast the machine is run.

The advantage of this attachment is that it gives engine lathe accuracy to turret lathe threading—and it gives much more than engine lathe speed.

Hartness Automatic Die

Wide Range **Few Dies** **High Accuracy** **Small Expense**

The No. 1 Die threads from $\frac{9}{32}$ inch to $\frac{9}{16}$ inch diameter, all pitches. The entire range from ¼ inch to 2¾ inches for standard threads, and to 3 inches for 8 pitch or finer, is covered by three sizes of dies whose ranges overlap.

Any of these dies, even the large No. 9, will thread pitches as fine as 32 per inch on its largest diameter without danger of stripping.

The lead-controlling feature is exclusive with this die. You can cut long threads as accurate in pitch as you will get from the ordinary engine lathe.

MACHINE COMPANY

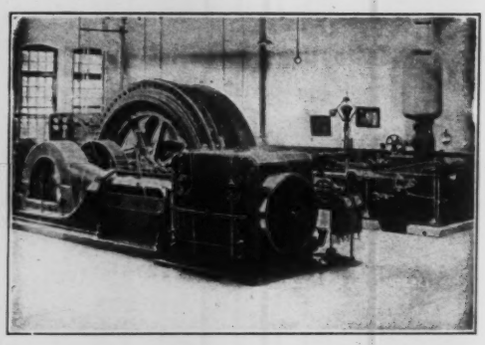
VERMONT, U.S.A.

Street, London, E. C.

Düsseldorf. France, Spain and Belgium: F. Auberty & Co., 91 Rue de Maubeuge, Paris

HAMILTON CORLISS ENGINES

"The Standard of Merit"



Are universally recognized as "Standard of Merit" and are found in every manufacturing center the world over, because they combine economy, durability and reliability to the utmost degree.

Let us send you our catalogues of our engines and details of their excellent design and simplicity, obtained through our experience in designing and building engines dating back almost to the inception of the Corliss idea of valve control and operation, a tale of high economy and satisfactory service that will be of value to you in enabling you to secure the equipment best suited to meet your requirements.

THE HAMILTON CORLISS records command your investigation. Why not let your next engine installation be a HAMILTON CORLISS?

Write for Bulletin "J. A."

THE HOOVEN, OWENS, RENTSCHLER CO.

HAMILTON CORLISS ENGINE WORKS, HAMILTON, OHIO

OFFICES IN ALL LARGE CITIES

FULTON

Oil and Steam Engines

Are Backed by Our Reputation for Reliability
"Sixty Years of Successful Manufacturing"

We build our machinery complete in our own plant. Long experience has demonstrated the proper materials to be used in our castings and our workmanship is of the highest class.

Fulton-Tosi Oil Engines, Diesel Type
Fulton-Corliss, Medium and High Speed Engines

Write for Oil Engine Bulletin "A."

FULTON IRON WORKS

1259 Delaware ST. LOUIS, MO.

Harris-Corliss Engine & Machine Co.

BUILDERS OF IMPROVED HARRIS-CORLISS ENGINES WITH BROWN PATENTED RELEASING VALVE GEAR

Rebuilding and Repairing Engines

BREAK-DOWN JOBS GIVEN SPECIAL ATTENTION

The durability and economy of Harris-Corliss Engines are phenomenal. Second-hand units command good prices and are always in demand. When rebuilt they carry the same guarantees as new engines.

LATHES

Special Machinery built to order

PROVIDENCE, R.I., U.S.A.

OTTO

Concerning the high cost of Gasoline

With gasoline averaging about twice as expensive as a year ago, every drop above a certain minimum that is consumed by a gasoline engine represents merely so much direct money wasted.

The service records that thousands of OTTOS have made since 1876 have proved conclusively that the heavy, sturdy, long-stroke, slow-speed OTTO develops its horse-power with the smallest gasoline—and oil—consumption.

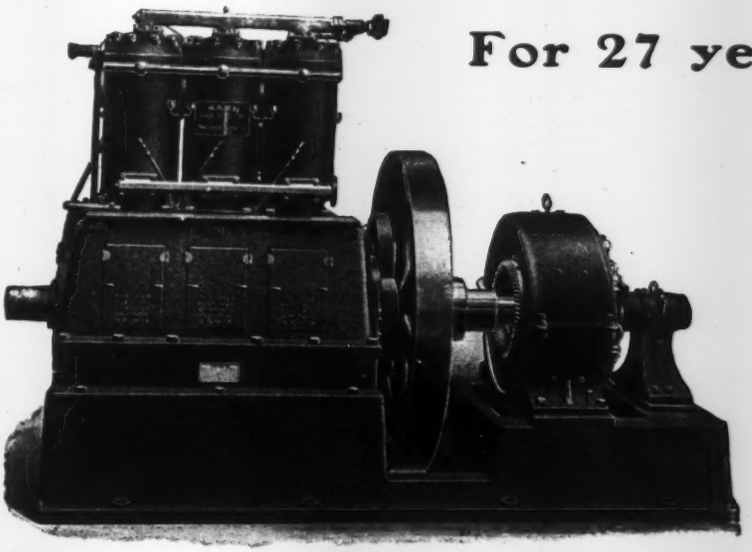
Your request will bring data on any type of internal combustion engine.

The OTTO Gas Engine Works

3219 Walnut Street . . . . Philadelphia
15 and 17 So. Clinton Street . . . Chicago
114 Liberty Street . . . . . New York

Gas and Gasoline Engines

THE NASH ENGINE



For 27 years the leader in Vertical Gas Engine Design

Specially adapted for

Electric Generation
Water Works
and high grade
Power Plants

NATIONAL METER COMPANY

CHICAGO NEW YORK BOSTON

Mackintosh, Hemphill & Co.

Pittsburgh, Pa.

ENGINES

Single and Compound, Corliss
Reversing and Blowing

Rolling Mill and Hydraulic Machinery

OF ALL KINDS

Shears, Punches, Saws, Coping Machines

ROCHESTER

Automatic Lubricators

For use on all types of steam engines and pumps and air and ammonia compressors.

Send for literature

SOLE MANUFACTURERS

GREENE, TWEED & CO.
109 DUANE STREET,
NEW YORK

The Pickering Governor

Standard in Steam practice everywhere.

Pickering principle of jointless construction insures closeness in regulation, continued efficiency and maximum durability.

For Steam Engines and Turbines, Gas Engines, Mechanical Control and Speed Limit.

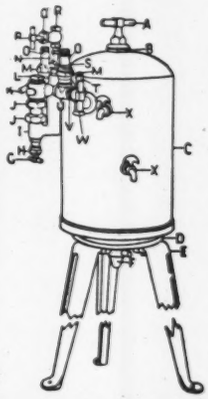
Particularly suited to Variable Speed Engines.

We offer you our service with over fifty years successful experience.

The Pickering Governor Co.
PORTLAND, CONNECTICUT

"Lackawanna" Series Lubricator

Designed to furnish lubricant to a series of cylinders from the one supply. Its special circulating pipe keeps a constant flow of fresh water through the sight glass, and the heating attachment keeps the oil at a uniform temperature. We have hundreds of endorsements.



Send for Circulars

CRESCENT MFG. CO.
SCOTTDALE, PA.

PIONEER
Inter-Pole Motors

For all electric drives—Constant or Adjustable Speed. All standard voltages.

Freedom from sparking—Heavy intermittent overloads.

Write us on your motor problems. Bulletins mailed on request.

Electro Dynamic Company
BAYONNE, N. J.

LIKE THE PYRAMIDS
BUILT TO LAST

Motors, Generators, Transformers

In All Sizes; In All Types; For All Purposes

Write for details

CROCKER-WHEELER COMPANY
AMPERE, N.J.

Baltimore Cincinnati Birmingham Cleveland Boston Denver Chicago Detroit
New Haven Pittsburg Newark St. Paul New York San Francisco Philadelphia Syracuse

Connelly Water Tube Boilers

are built in units from 100 hp. to 4,000 hp. and for pressures up to 300 lb. They have 100% tube area in the path of the circulation, deliver steam superheated from 5 to 15 deg. at any rating, and can be operated at 200 to 300% of rating. The boiler has no flat surfaces, no staybolts, braces or crown bars. Open four manholes and boiler is ready for inspection and internal cleaning.

Boiler here shown is carrying 300-lb. steam, has a superheater, giving a final steam temperature of 875 deg.

Send for bulletin "A"

The D. Connelly Boiler Co., Cleveland, Ohio

Founded in 1875 by Daniel Connelly

We have the most modern boiler manufacturing plant in America

Springfield Water Tube Boilers

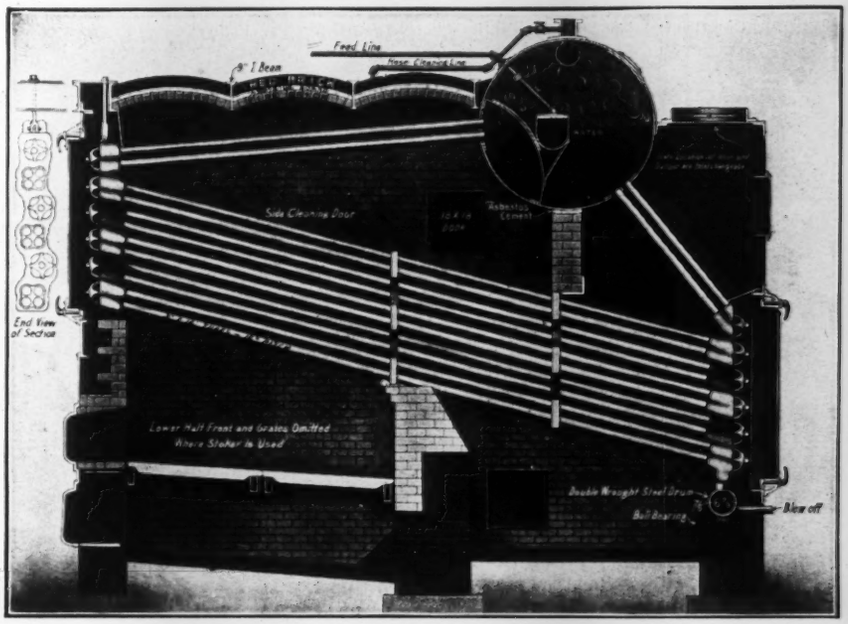
SECTIONAL—SINUOUS HEADERS
No Staybolts—NO Braces—NO Bent Tubes
Of ALL STEEL Construction

Each section suspended independent of all other sections.

Hand holes have inside plates of drop forged steel each covering four tubes.

65% less hand holes than other horizontal W. T. boilers.

Tubes pitched 15° and large circulating area between headers and drum insures rapid steaming.



A Sectional View of a Springfield Water Tube Boiler.

Occupy less space and require less brick than other horizontal W. T. boilers.

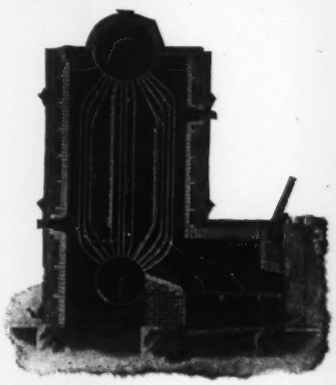
Having about 97% Tube heating surface—drum of large diameter and special dry pipe insures dry steam.

Baffles are indestructible and permit removal of any tube without disturbing other tubes or baffles.

Write for further information

Springfield Boiler & Manufacturing Co., Springfield, Illinois

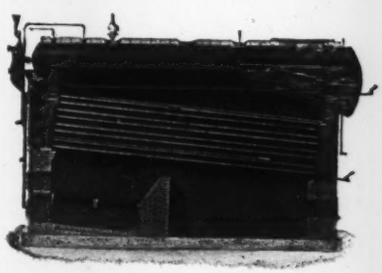
SAFER BOILERS



Erie City Vertical Water Tube Boiler

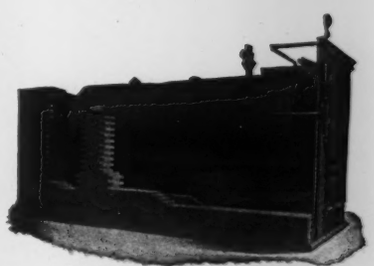
A signal event for the boiler industry was the completion of the A. S. M. E. Boiler Code. This report, containing standard specifications for the construction, equipment and use of steam boilers, embodies the collective knowledge of the world's best experts. Its adoption by the Society marks a new era in the manufacture of steam boilers, and will prove the inauguration of a great movement for the protection of human life and property.

Erie City "Economic" Boiler



Erie City Horizontal Water Tube Boiler

We are now building all types of boilers to meet the specifications of the A. S. M. E. Boiler Code.

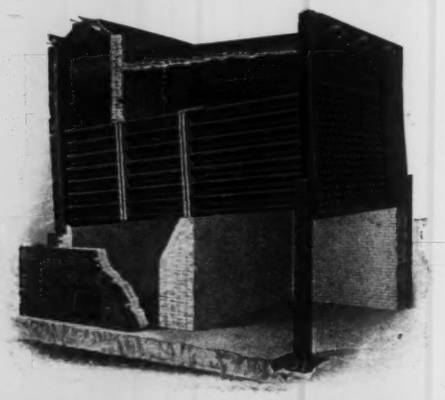


Erie City Return Tubular Boiler

ERIE CITY IRON WORKS, Erie, Pa.

Manufacturers of Steam Engines and Boilers and Feed Water Heaters; Horizontal and Vertical Water Tube Boilers; Lentz Engines

The Special Features Assuring
Economy, Efficiency and Durability
are to be found in



EDGE MOOR WATER TUBE BOILERS

These cannot be explained in the limited space of an advertisement. Those interested in steam boilers and in tests of unusual performances should send for our illustrated bulletins. The details of design and construction which assure a minimum of heat losses, low fuel cost, and general all round reliability and satisfactory service are fully given. The Edge Moor boilers

Meet the Exacting Conditions of Modern Power Plants and are Especially Suitable for those of Large Size

Our Literature Will Show Why; Send for It

Edge Moor Iron Company

Edge Moor, Delaware

New York Boston Chicago St. Paul

Sec Our Data 1910 A. S. M. E. Condensed Catalogues of Mechanical Equipment

Heine

ENGINEERS:

Send for a copy of the booklet

"SUPERHEATER LOGIC"

It discusses the Design of Heine Boilers and Their Operation. Also ask for pamphlet "Large Heine Boilers."

HEINE SAFETY BOILER CO.

2465 East Marcus Ave. St. Louis, Mo.

Boilers

SMITH GAS PRODUCERS

Deliver Clean, Cold Gas for

FUEL AND POWER SERVICE

They are being installed in up-to-date plants instead of Hot Gas Producers, Powdered Coal, Fuel Oil or City Gas for Industrial Heating and instead of Steam Boilers or Oil Engines for Power.

Write for Catalog 9E

THE SMITH GAS ENGINEERING CO.

LEXINGTON, OHIO

Sole Canadian Representatives:
The Canadian Allis Chalmers Ltd., Toronto, Canada.

KEELER WATER TUBE BOILER BUILT BY E. KEELER CO. WILLIAMSPORT, PA. U. S. A.

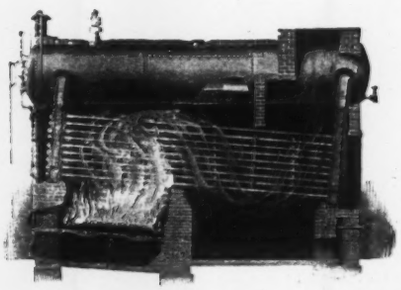
ESTABLISHED 1864

New York Rochester
Philadelphia Pittsburgh
Cleveland Chicago
Dallas San Francisco

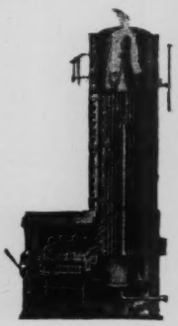
Keeler Water Tube Boilers

No feature of its design is excelled. All Wrought Steel Construction, Straight Tubes, Horizontal Drum, Vertical Baffle Walls, Rear Casing, perfect equipment, accessible and compact. This boiler is the result of fifty years of boiler shop practice. Built in units 75 to 1500 Horse Power.

Ask for new illustrated catalog



Sec Our Data 1910 A. S. M. E. Condensed Catalogues of Mechanical Equipment



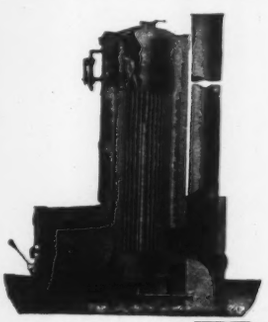
Wickes Vertical Water Tube Boiler

Ask us why engines are never wrecked and steam turbines never have erroded and clogged blades and nozzles when using this boiler?

Ask us for full data—sent free

THE WICKES BOILER CO.

SAGINAW MICHIGAN, U. S. A.



SALES OFFICES:

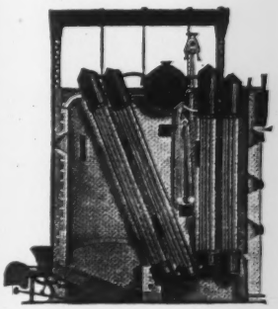
New York City, 1417 West St. Bldg.
Buffalo, 269 Richmond Ave.
Chicago, 76 West Monroe St.
Pittsburgh, 904-5 Empire Bldg.
Boston, 201 Devonshire St.
Detroit, 1116 Penobscot Bldg.
Seattle, 410 White Bldg.

Sec Our Data 1910 A. S. M. E. Condensed Catalogues of Mechanical Equipment

The Bigelow-Hornsby Water Tube Boiler

Features of the Bigelow-Hornsby Boiler that meet the requirements of Modern Power House Practice:

1. Unlimited size of units.
2. Small ground space occupied.
3. Coldest water meets the coldest gases.
4. Direct heating surface about four times as great as the average water tube boiler.
5. All parts, both external and internal, readily accessible.
6. All boiler tubes perfectly straight.
7. Circulation of water and liberation of steam unrestricted.
8. Very dry steam, also ample room for superheaters where required.
9. High continuous economy due to extreme cleanliness of the most efficient heating surface.



Cross Sectional View Through the Brickwork

10. Arrangement of baffling is unique, causing the gases to pass over the heating surface in thin streams and uniformly at every point.
11. Furnace arrangement is ideal for securing perfect combustion, as furnace is correctly shaped and of ample size.
12. Greatest flexibility, both as to construction and in steaming qualities.
13. No cast iron used in any portion of the boiler proper.
14. Constructed both as to workmanship and material in accordance with the most advanced boiler practice.

THE BIGELOW COMPANY

New York Office
85 Liberty St.

Works and Main Office
76 River St., NEW HAVEN, CONN.

Boston Office
141 Milk St.

Also Manufacturers of the Bigelow-Manning and Horizontal Return Tubular Boilers, Digesters, Crystallizers, Vulcanizers and Heavy Plate Steel Work

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

WATER TUBE STEAM BOILERS

STEAM SUPERHEATERS **MECHANICAL STOKERS**

Works: BARBERTON, OHIO BAYONNE, N. J.

BRANCH OFFICES

BOSTON, 35 Federal Street
PHILADELPHIA, North American Bldg.
SAN FRANCISCO, Sheldon Bldg.
PITTSBURGH, Farmers Deposit Bank Bldg.
NEW ORLEANS, 533 Baronne St.
DENVER, 435 Seventeenth St.
SALT LAKE CITY, 705-6 Kearns Bldg.
TUCSON, ARIZONA, Santa Rita Hotel Bldg.
CHICAGO, Marquette Bldg.
ATLANTA, GA., Candler Bldg.
CLEVELAND, New England Bldg.
SEATTLE, Mutual Life Bldg.
HAVANA, CUBA, Calle de Aguiar 104
LOS ANGELES, I. N. Van Nuys Bldg.
CINCINNATI, O., Traction Bldg.
HOUSTON, TEXAS, Southern Pacific Bldg
SAN JUAN, PORTO RICO, Royal Bank Bldg.

Genuine Charcoal Iron Boiler Tubes

MADE from the same grade of Charcoal Iron which we formerly furnished the Allison Manufacturing Company for all their tubes, are practically free from pitting and corrosion, and will withstand 400° more heat than steel tubes.

We are in position to furnish these tubes to conform to requirements of the A. S. M. E. Boiler Code.

PARKESBURG IRON COMPANY
Parkesburg, Pennsylvania
NEW YORK OFFICE, . . 30 CHURCH STREET

SUPERNO SUPERheaters

SUPERior to all other Makes

WHY?

SUPERNO eliminates drop in pressure.
SUPERNO eliminates all causes of inefficient lubrication.
SUPERNO produces uniform SUPERheat—150 to 400 degrees Fahrenheit—for every type of boiler, from 100 to 2500 horsepower.
SUPERNO saves fuel, space, and time in the production of steam power.

SUPERNO COMPANY, Inc.
52 Broadway, NEW YORK.

You Burn Coal

Are You Troubled With It?

OUR

TYPE "E" STOKERS

UNDERFEED FOR BITUMINOUS COAL

Coxe Stokers

FOR ANTHRACITE COAL AND

Coke Breeze

Will Burn Your Coals Successfully. Our Business is to Help You Solve Your Combustion problems.

Have Our Engineers Consult with You.

COMBUSTION ENGINEERING CORPORATION NEW YORK

Combustion Engineering Corporation

Owners and manufacturers of

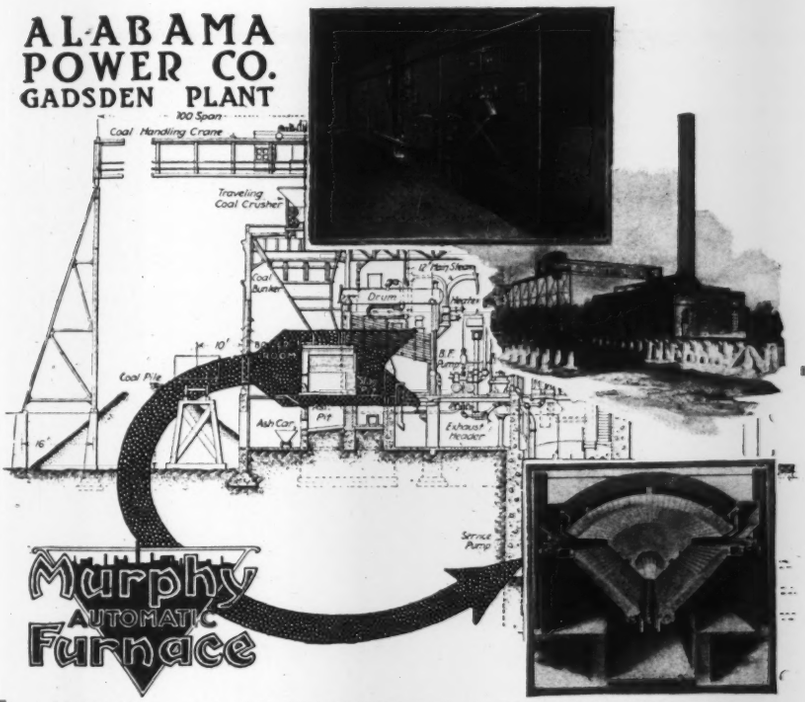
Type "E" Stoker—For Bituminous Coal. The Grieve Grate—For All Hand-Fired Fuels

Sole Representatives

Coxe Traveling Grate Co.—The Automatic Anthracite Stoker

NEW YORK CITY, 11 Broadway
PHILADELPHIA, PA., 718 Lincoln Bldg.
PITTSBURGH, PA., Geo. J. Hagan Co.
CHICAGO, Fisher Bldg.
SALT LAKE CITY, American Stoker Co.
HAZLETON, PA., Markle Bank Bldg.
BOSTON, MASS., Schumaker-Santry Co.
MINNEAPOLIS, MINN., Pocock & Pollard Co.
BIRMINGHAM, ALA., Keiser-Geismes Engr. Co.

ALABAMA POWER CO.
GADSDEN PLANT



Murphy Furnaces are applied to 6-600 H.P. Boilers in this plant of the Alabama Power Co.

39 Years of Furnace Building

plus the broad and ripe experience we have had working out combustion problems enable us to meet your special needs for a better and more economic furnace.

Consult us fully—no obligations. Ask for Catalog "B."

MURPHY IRON WORKS
DETROIT MICH. U. S. A.

254

Solving the Power Plant Fuel Burning Problem

Hundreds of Power Plant Operators of the Big, nationally known institutions have voluntarily testified to the economy and efficiency of operation of their boiler plants brought about through the use of Murphy Automatic Furnaces applied to their boilers.

The sum total of the benefits received and—emphasized in their reports is best expressed as follows—

Higher Efficiency and Capacity with Minimum Maintenance

This is a short, concise, all-in-a-nut-shell description of the combustion service received from every installation of the Murphy Furnace.

Through scientific and automatic handling of coal, air and ashes the Murphy Automatic Furnace is accomplishing results of great economic importance to the management of every manufacturing plant, large or small.

You can apply the Murphy to any type of boiler of any size unit in your plant. Burns slack and other low cost fuels. Effectively handles the Peak, Medium and Light Loads of the Power Service Plant.

Automatic in All Its Functions

The Murphy differs from the ordinary Stoker in that it is automatic in all of its functions. It not only provides automatic feed of fuel, automatic stoking or breaking of the coke or coal but it also automatically removes all ash and refuse.

Green Chain Grate Stokers

GREEN ENGINEERING CO.
EAST CHICAGO, IND.

Bulletins on Request

Geco Steam Jet Ash Conveyors

RILEY UNDERFEED STOKERS

The Stoker with the Reciprocating Retort Sides

SANFORD RILEY STOKER CO., LTD.
Worcester, Mass.

Sales inquiries direct to home office, Worcester, or branch offices of B. F. Sturtevant Co., Sales Agents. British Licensees, Erith's Engineering Co., Ltd., London.

D-6

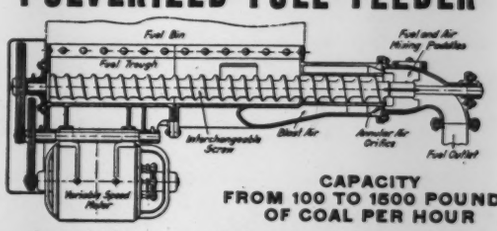
KOERTING MULTI-JET
CONDENSERS

Will give 28" Vacuum with 70° water, *without the use of an air pump*, as the condensing nozzles, or jets, act at the same time as their own air pump. The Koerting condensers have no moving parts—just a pump to deliver the condensing water under a low head—therefore wear and tear nil.

Catalog 5-AB sent upon request

SCHUTTE & KOERTING CO.
1239-57 N. 12TH STREET
PHILADELPHIA, PA.

PULVERIZED FUEL FEEDER



CAPACITY
FROM 100 TO 1500 POUNDS
OF COAL PER HOUR

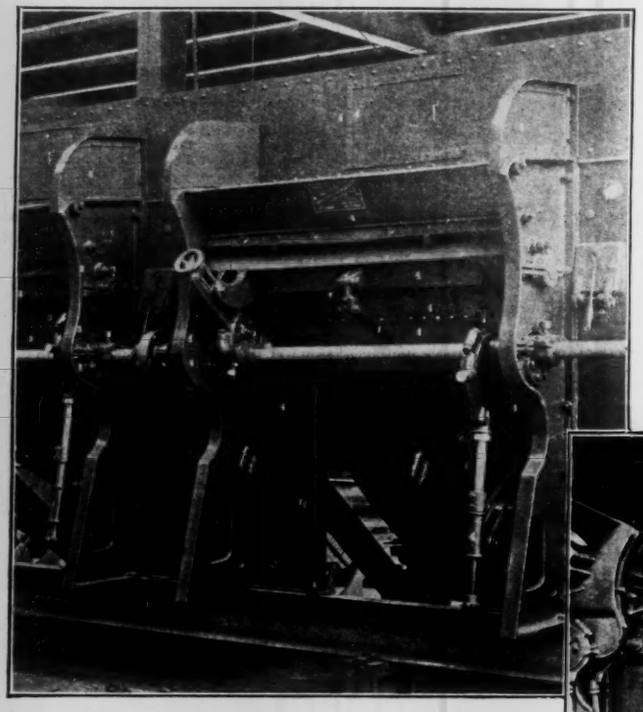
Is adapted for any existing installation, comparative operating advantages being thorough commingling of fuel and air, uniform feed, and low delivery pressure.

Consult us about your steam or metallurgical fuel problems.

Locomotive Pulverized Fuel Company
30 CHURCH STREET NEW YORK CITY

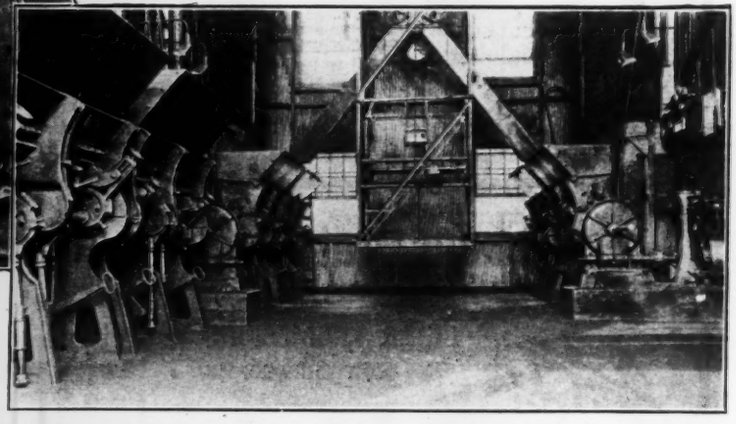
WETZEL STOKERS

For Manufacturing Plants



Compare Their Simplicity With Any Other Stoker

Everything You Need and Nothing You Do Not Need



Wetzel Automatic Mechanical Stokers, when installed under the boilers in a **manufacturing** plant, fit the needs of that plant exactly without imposing the burden of complications and features for which a manufacturing plant has no use.

They require no skilled labor. They are foolproof. They assure absolutely smokeless conditions with **natural draft** and save the cost of the steam necessary to operate blower apparatus. They save money on cost, installation and maintenance.

If your combustion problems are those encountered in the boiler rooms of factories, the Wetzel Mechanical Stoker will take care of every operating condition. Wetzel Stokers are doing this in over 400 plants, operating approximately 350,000 horsepower.

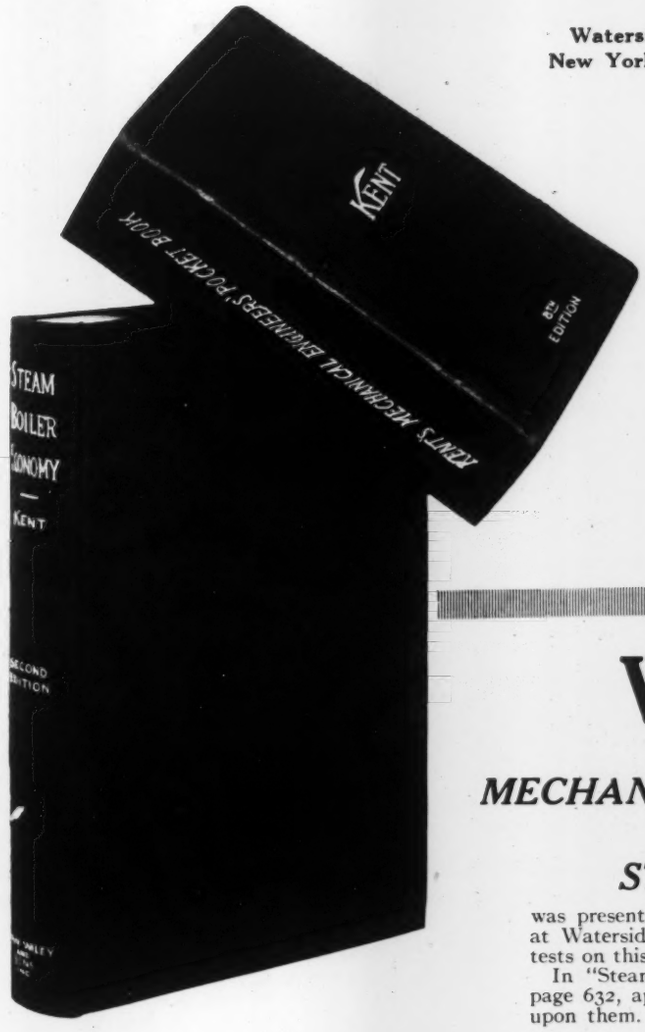
Write for New Catalog

Ask for a copy of this handsome book. After looking it over you'll see exactly why Wetzel Stokers are the stokers you should install.

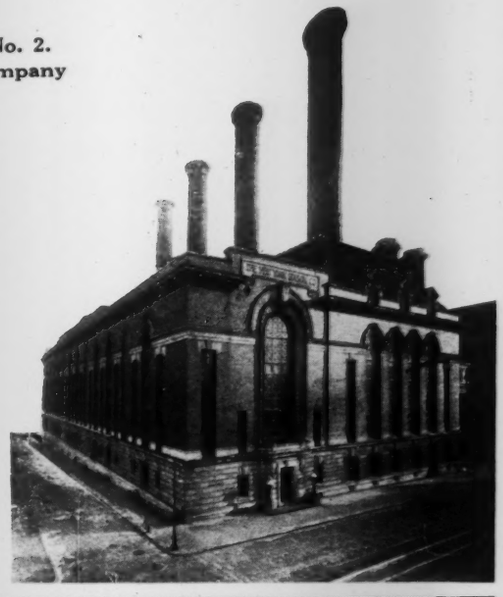
The Wetzel Mechanical Stoker Co.

of New York, Inc.

30 Church Street - - - - New York



Waterside Station No. 2.
New York Edison Company



William Kent

Author of the

MECHANICAL ENGINEERS' POCKET BOOK

and of

STEAM BOILER ECONOMY

was present in 1907 at tests of a 640 H. P. TAYLOR Stoker, installed at Waterside Station No. 2 of the New York Edison Company. The tests on this stoker exhibited some surprising figures.

In "Steam Boiler Economy," by Mr. Kent, Second Edition, 1915, page 632, appears the following results of these tests and his comments upon them.

W/S . . . . . lbs.	3.55	3.74	4.12	4.45	4.52	4.61	4.61	4.65	4.79	4.82	4.99	6.30	6.51
E . . . . . %	73.1	74.2	79.3	80.7	80.9	78.7	75.8	80.7	75.1	80.7	77.6	76.6	74.5
E1, by formula . .	81.4	81.0	80.3	79.6	79.5	79.3	79.3	79.2	78.9	78.9	78.5	75.9	75.5
Diff. E1–E	−8.3	−6.8	−1.0	+1.1	+1.4	−0.6	−3.5	+1.5	−3.8	+1.8	−0.9	+0.7	−1.0
Radiation, etc. . %	14.6	14.6	10.0	6.8	7.7	9.1	13.0	8.3	13.6	7.7	13.0	12.5	15.1

The formula with which the boiler efficiency E is compared is E = 82.5—2 (W/S—3). It is obtained by plotting the efficiencies obtained at rates of evaporation in excess of 4 lb. per sq. ft. of heating surface per hour. The results are somewhat erratic, and the variation in composition of the flue gases (CO_2 10.9 to 16.5, 0, 1.3 to 7.9) is not sufficient to account for them. It is noticeable that all the results that show efficiencies lower than those calculated from the formula also show high losses due to radiation and unaccounted for. The actual loss by radiation was probably not much in excess of 1%. The unaccounted for loss may be largely due to incomplete combustion of CH_4 distilled from the coal and of H from the decomposition of moisture in the coal, which was rather high (2.2 to 4.0%) for semi-bituminous. The great fluctuations in the unaccounted for loss under conditions that were uniform so far as could be ascertained indicate errors in the coal measurement, due to the fact that the tests were not over 8 hours long, and the difference in quantity and condition of the coal on the grates at the beginning and end of a test might be considerable. The furnace conditions were not the most favorable for high economy at rapid rates of driving, for the stoker was installed in the old setting of the boiler which had only a moderate sized combustion space. The temperature of the chimney gases was low in all the tests, ranging from 418° F. for W/S = 3.55 to 519 for W/S = 6.51. At the date named (1907) the efficiencies were the highest that had ever been obtained at rates of driving in excess of 4 lb. from and at 212° per sq. ft. of heating surface per hour.

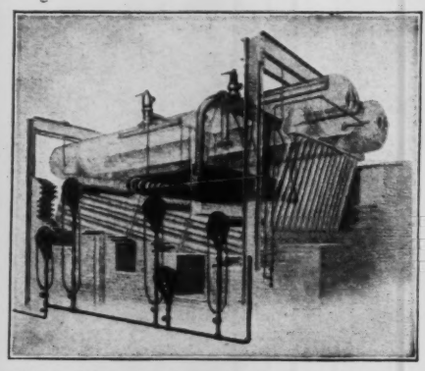
Waterside Station No. 2 today has a total of 86 TAYLOR Stokers under as many boilers.

AMERICAN ENGINEERING CO., PHILADELPHIA, PA.

The Taylor Stoker

DIAMOND SOOT BLOWERS

"A Paying Investment"



Diamond Blowers Installed on B and W Boiler.

Annual Sales Year ending Aug. 1, 1916 Exceeded 600,000 H. P.

Send for Bulletins 118 and 119

The Diamond Mechanical Soot Blower System will effect:

1. **FUEL, a saving of from 4 to 11 per cent;**
2. **BOILER EFFICIENCY, an increase of 4 to 8 per cent;**
3. **LABOR, a saving of many hours per day;**
4. **LONGEVITY, an increase in the length of service of boiler flues through prevention of corrosion;**
5. **STEAM, a saving of 25 to 75 per cent of steam used for cleaning.**

It's pretty convincing evidence, isn't it, of the fact that Diamond Blowers, are a paying investment, when such discriminating buyers as those noted below, buy them year after year, as their power plants are extended? All are repeat purchasers.

U. S. Steel Corporation
Quaker Oats Co.
Standard Oil Co.
Singer Manufacturing Co.
New York Central Lines
Canadian Pacific Railway Co.
Detroit Edison Co.
Stone & Webster Engineering Co.
Ford Motor Car Co.
Atlantic Refining Co.
General Electric Co.
American Tobacco Co.
International Harvester Co.
Coastwise Transportation Co.
Westinghouse, Church, Kerr Co.
American Sugar Refining Co.

Diamond Blowers are designed for every type of Boiler—and every Boiler needs them. As an investment they are frequently found to PAY FOR THEMSELVES IN ONE YEAR. Complete information furnished gladly.

May we tell you about the new metal—Insuluminum?

DIAMOND POWER SPECIALTY COMPANY

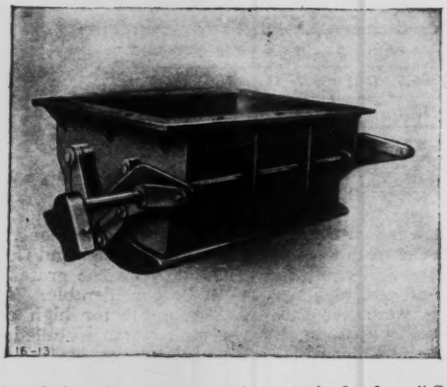
Main Office:

CHICAGO PHILADELPHIA **DETROIT** NEW YORK BOSTON

CANADIAN BRANCH: DIAMOND SPECIALTY COMPANY, WINDSOR, ONT.

HUNT ASH PIT VALVES

Are "Workable Always"



Designed for the severe service required of a "Cutoff" for the ash pit, they meet these strenuous requirements perfectly. The body is heavy ribbed cast iron—and the jaws strong enough to break up clinker—the operating mechanism simple and powerful. The valve does not stick—and can be easily operated from any convenient point.

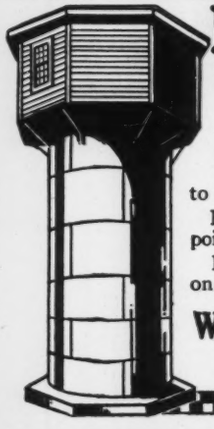
Made in a number of different sizes from 8 inches square to the large 24 x 36 inch valve illustrated.

If the removal of ashes from your boiler ash pits is the sore spot in your plant, write us. A new 32-page catalogue, No. S 15-3, fully describing our complete line of gates for coal, gravel, ore, sand, fertilizer materials, coke, etc., is just coming off the press. Ask for *your* copy.

C. W. HUNT CO., INC.

WEST NEW BRIGHTON, N. Y., U. S. A.

61 Broadway, N. Y. City Fisher Bldg., Chicago
Munsey Bldg., Washington



BARTLETT-GRAVER WATER SOFTENER

Automatically removes scale forming and corrosive matter from water at an average cost of from 1c to 2c per 1000 gallons.

Results guaranteed from every standpoint.

Detailed information gladly furnished on request.

Wm. Graver Tank Works
4854 Tod Ave., East Chicago, Ind.

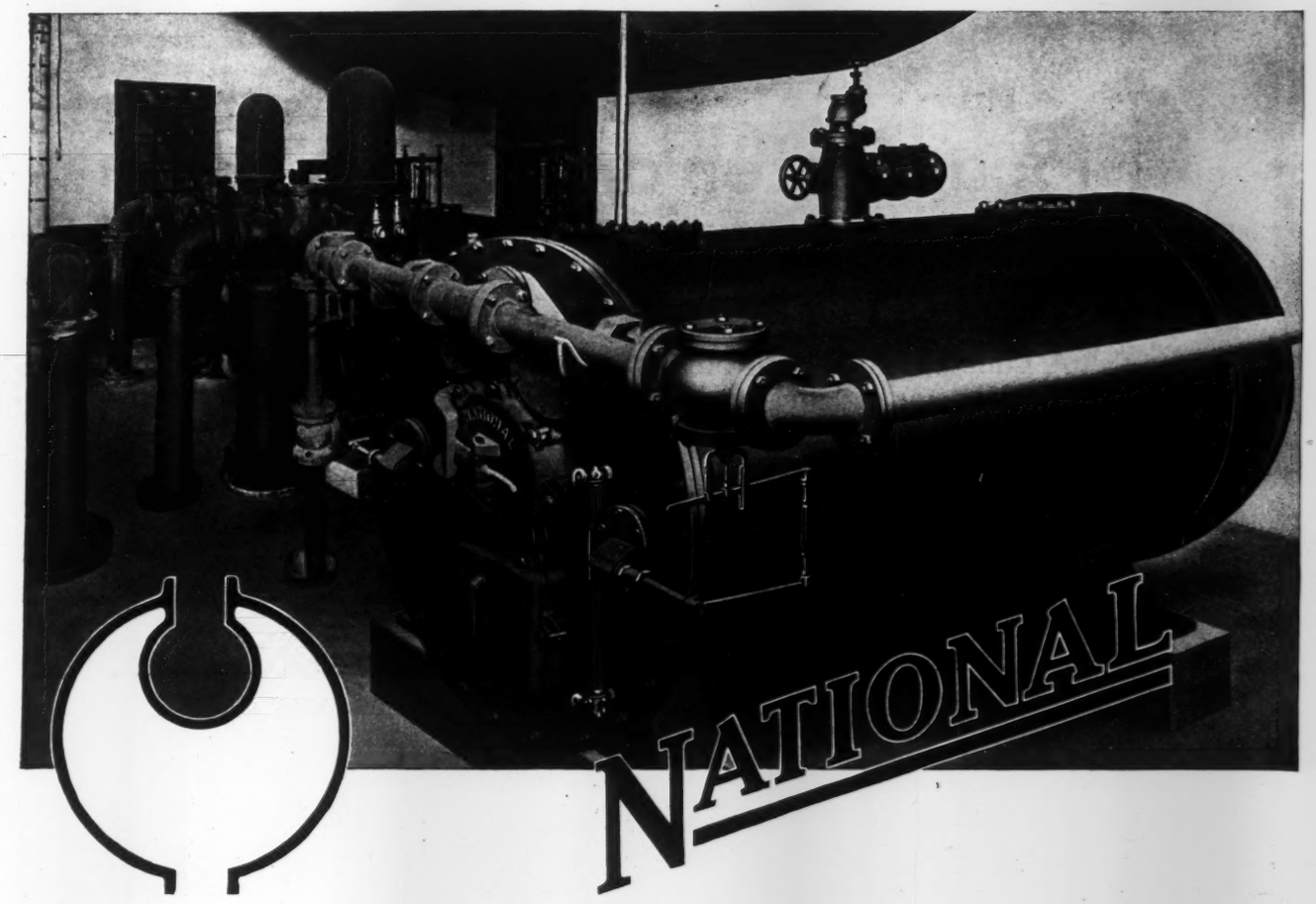
WATER PURIFICATION

WE-FU-GO and SCAIFE
Softening and Filtering Systems
for ALL PURPOSES

WM. B. SCAIFE & SONS CO.

Founded 1802

221 First Ave. **Pittsburgh, Pa.**
26 Cortlandt St. **New York, N. Y.**



The Contact Pipes are of this section. The smaller or inner pipe is always filled with water and surrounded with the exhaust steam. Water overflows the top, follows around the large pipe, and falls from the bottom in the form of spray which mingles with the exhaust steam.

The Manufacturer's Power Plant

Every Consulting Engineer and Manufacturer having a steam power plant should read the new catalog describing

NATIONAL
DIRECT CONTACT
FEED WATER HEATERS

It tells about the latest type of open feed water heater. It describes the heater which not only supplies the boilers with plenty of pure hot water, but has great capacity for storing large quantities of hot water for all industrial purposes.

This catalog will show you why the patented contact pipes is the one best way to heat the water, and why upward filtration relieves the engineer of extra work.

This catalog is No. 52—send for it. 46-113

THE NATIONAL PIPE BENDING COMPANY

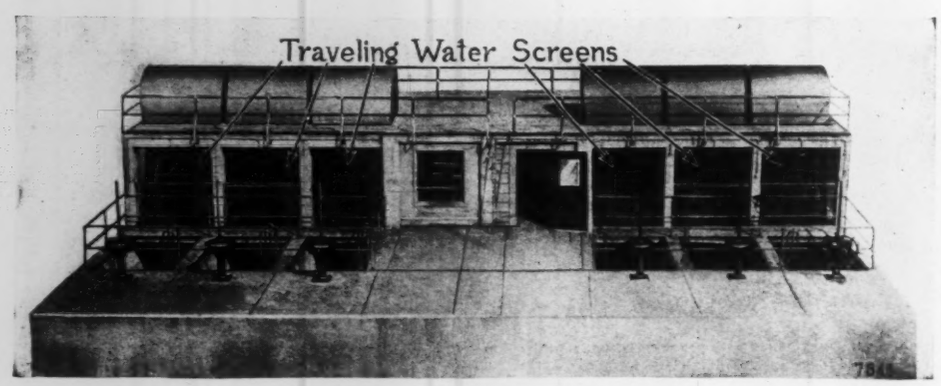
54 High St., Boston NEW HAVEN, CONN. 149 Broadway, New York

Flood Water or Dog Days

Have no terrors for the power plant fortified with

Link-Belt Traveling Water Intake Screens

A constant supply of clean condenser water is assured. All floating trash, debris, driftwood, etc., is screened and carried up and away from the intake. The operation is automatic, and requires little attention.



Link-Belt Water Intake-Screens comprise two strands of Link-Belt carrying suitable screens, traveling over sprocket wheels, the whole forming a unit supported by a steel framework. Usually several units are required to protect the face of the intake. Each unit occupies its own compartment in the forebay.

When operating the screens pass slowly before the intake opening, carrying trash with them, until they start on the return from the head. Here a powerful stream of water washes the screens clean, and disposes of the trash.

Six Reasons Why You Should Use Link-Belt Traveling Water Intake Screens

1. They Never Clog. 2. They Never Freeze Up. 3. The Screen Surfaces Always Accessible. 4. They are Self-cleaning. 5. Large Intake Area (full opening of intake always available). 6. Operate at very Slow Speed (small power consumption).

Write for Booklets Nos. 229 and 293, describing Link-Belt Traveling Water Intake Screens.

LINK-BELT COMPANY

PHILADELPHIA INDIANAPOLIS

New York.....299 Broadway
Boston.....49 Federal St.
Pittsburgh.....1501 Park Bldg.
St. Louis..Central Nat. Bank Bldg.
Buffalo.....698 Ellicott Square
Cleveland....1304 Rockefeller Bldg.
Detroit.....732 Dime Bank Bldg.
Wilkes-Barre..2nd Nat. Bank Bldg.
Minneapolis.....418 So. Third St.
Louisville, Ky..F. Wehle, Starks Bldg.
Seattle.....580 First Ave., S.
Portland, Ore...14th & Lovejoy Sts.
Los Angeles..161 N. Los Angeles St.
Denver, Lindrooth, Shubart & Co., Boston Bldg.
San Francisco, N. D. Phelps, 461 Market St.
New Orleans, C. O. Hinz, Hibernia Bank Bldg.
Knoxville, Tenn.....Empire Bldg.
Birmingham, D. T. Blakey, 309 Am. Trust Bldg.
Toronto Canadian Link-Belt Co., Ltd.

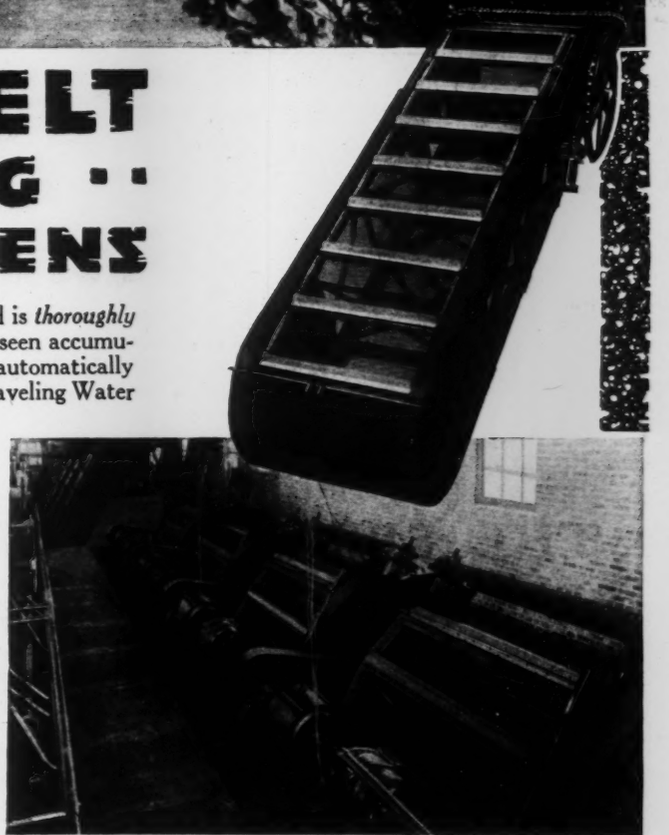
1/3'd of This River's Flow Goes Through

CHAIN BELT
•• TRAVELING ••
WATER SCREENS

Think of it! One third the flow passes through and is *thoroughly screened*. A constantly growing pile of refuse may be seen accumulating at the point where the traveling water screen automatically deposits this debris. A battery of seven Chain Belt Traveling Water Screens does this work for the Commonwealth Edison Company's Northwest Station located on a branch of the Chicago River. This installation saves labor inside the plant by lessening the necessity for frequent condenser cleaning—outside, by doing away with all hand labor which was necessary in the older type of screens.

All fear of shutdowns frequently caused by clogged intakes is eliminated as the Chain Belt Traveling Water Screens are unaffected by excess refuse, ice, or rise and fall of the water level within the height limits of the screen. Not only the large power plants, but the smaller industrial plants may also be largely benefited by these installations. In fact, any plant requiring large volumes of clean water will do well to look into the possibilities of these screens.

Send for our Traveling Water Screen Bulletin No 64 S.
No obligation incurred—just write.

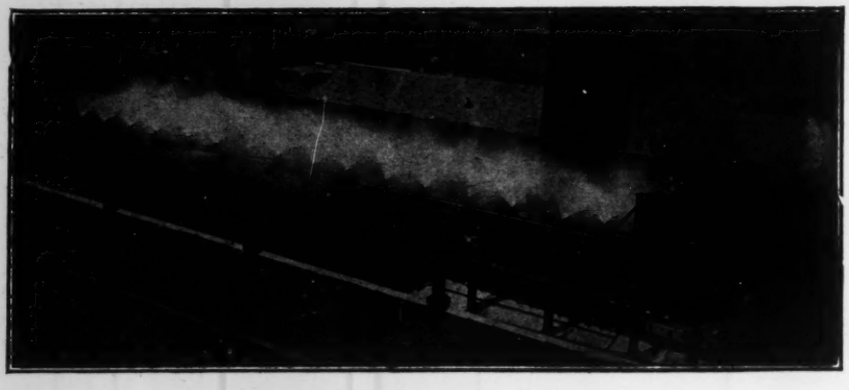


UPPER PICTURE—Exterior Commonwealth Edison Power Co's. Screen House.
CENTER PICTURE—Chain Belt Traveling Water Screen.
LOWER PICTURE—Inside Screen House showing battery of seven Chain Belt Traveling Water Screens.

CHAIN BELT COMPANY
734 Park Street Milwaukee, Wis.

GREETINGS
The Season's Greetings to you and yours, with the sincere wish that during the coming year you will be blessed with happiness and prosperity.
The Lunkenheimer Co.
Cincinnati

32-9-4



One of Seven Installations for the American Ice Company

During the past three years

THE SPRAY ENGINEERING COMPANY

Has equipped over two hundred and fifty plants with

Spray Cooling Systems

Compared to a cooling tower of equal capacity, our Spray System costs much less to install, about one-half as much to operate and practically nothing to maintain.

If the lowering of cost interests you, write us

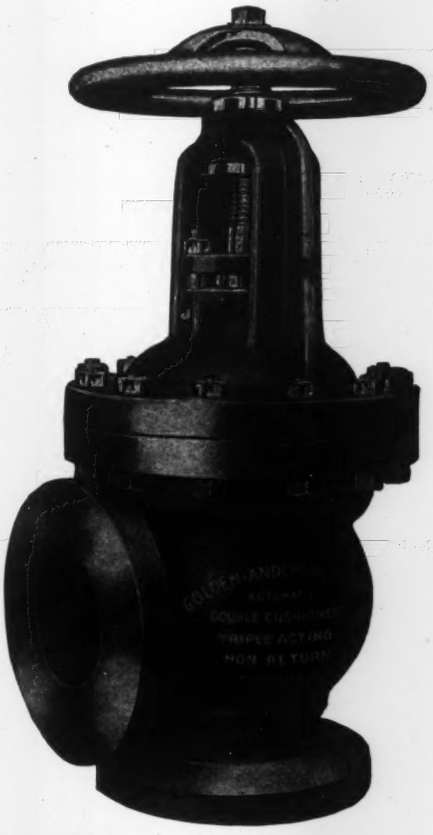
SPRAY ENGINEERING COMPANY

93 Federal St. **Boston, U. S. A.**

Cable Address: Spraco/Boston

Code: Western Union

U. S. Steel Corporation has ordered 1,288



Golden-Anderson Automatic Double-Cushioned Triple-Acting and Non-Return Valves

They work both ways protecting power plant—The boilers and steam lines. "Life and property insurance valves."

1st. Prevent expensive shut-downs.

2nd. Make back flow of steam impossible.

3rd. Equalize pressure between boilers, automatically—quickly pay for themselves in reduced coal bills alone.

4th. Absolutely protect men inside of "dead" boilers.

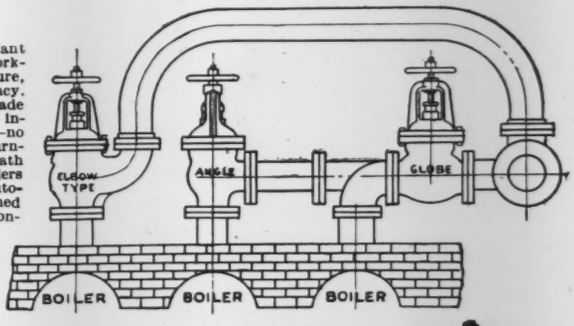
5th. Valves fitted with "Double Corliss" dashpots. Absolutely cushion valve—no hammering or sticking.

6th. Provide for every contingency by "automatic" testing in service feature—valves closed from floor or remote points.

7th. Heaviest and most correct mechanically-constructed and operated automatic valves made.

Make your power plant safe. Keep the boilers working at a uniform pressure, and at increased efficiency. Your workmen can be made safe when repairing the inside of a cold boiler—no danger of steam being turned in to scald them to death—by equipping your boilers with Golden-Anderson Automatic Double-Cushioned Triple-Acting or plain Non-Return Valves.

Write for Circular No. 505



Automatic Cushioned Steam Pressure Reducing Valves

Reduce, Automatically, High Pressure to Positive Low Pressure

FEATURES

1. Safe Operating Piston makes it impossible for high pressure to enter into low pressure service. Makes accidents impossible.
2. Thoroughly cushioned—no hammering, chattering or striking.
3. No auxiliary valves or small by-pass—Reliable and uninterrupted service.
4. Double extra heavy throughout—Practically indestructible.
5. Only one adjustment—on the outside. Valve always accessible.

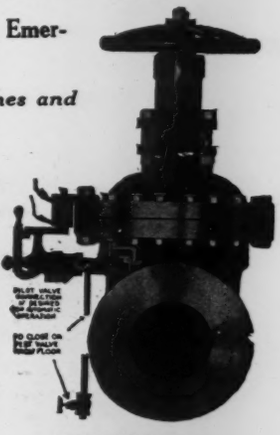
Double Cushioned Quick Closing Emergency Trip Valves

Provide Against Runaway Engines and Disastrous Accidents

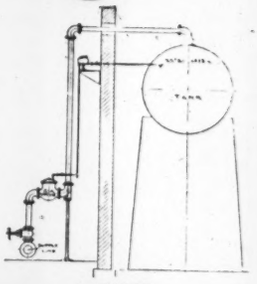
FEATURES

1. Electrically operated from distant points.
2. Emergency tripped by small branch pipe connection.
3. Hand operated by hand wheel.
4. Double cushioned by Corliss dash pots—Positively no hammering or pounding.
5. Double extra heavy throughout—Practically indestructible.
6. Suitable for any pressures—No adjustments required.

HOSTS OF REFERENCES



Write for Circular No. 505.



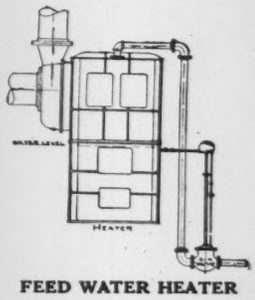
TANK

Golden-Anderson Patent Automatic Cushioned Controlling Float Valves

Especially Adapted for Maintaining Uniform Water Level in Feed Water Heaters, Tanks, Reservoirs, Vats, etc.

No Water Wastes—Economic—Durable—Reliable—Air and Water Cushioned—Virtually Indestructible.

Write for Circular No. 508



FEED WATER HEATER

Golden-Anderson Valve Specialty Co.

1228 Fulton Building, Pittsburg, Penna.

When economy demands

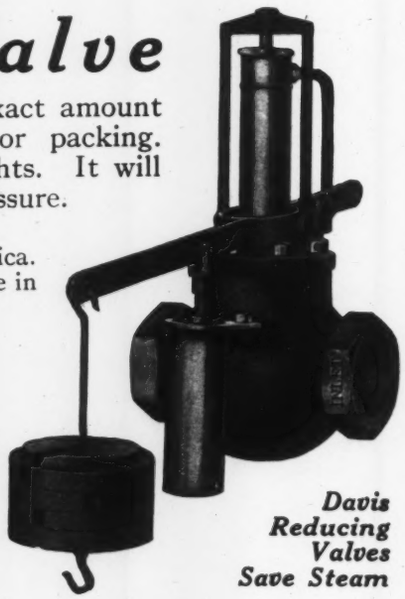
When your boiler pressure is too high—when economy or necessity demands the use of steam at a lower pressure—put the job up to a

Davis Reducing Valve

This automatic valve saves steam by delivering the exact amount required—no more. It has no diaphragm, springs or packing. It is a piston type of valve controlled by counterweights. It will reduce steam, air or water from any pressure to any pressure.

The Davis was the first successful reducing valve made in America. For forty years it has been a leader in its class. More of them are in use than any other make. They should be in your plant.

If your dealer can't supply you, we can. Send for General Catalog No. 8.



Davis Reducing Valves Save Steam

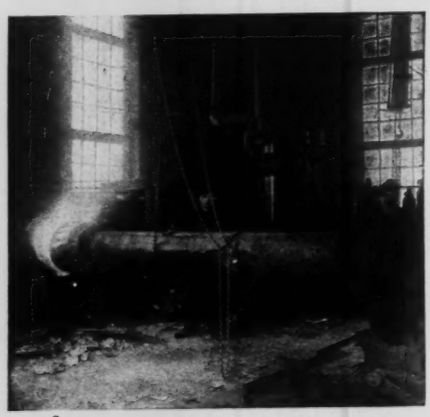
G. M. Davis Regulator Co.

439 Milwaukee Ave., Chicago

New York, Boston, Philadelphia, Baltimore, Pittsburgh, San Francisco

Valve Specialty Manufacturers Since 1875

Steel Valves, Steel Fittings Pipe Bend, Walmanco Flanges, Everything for Power Piping



We make a full line of such material of Walworth quality

Walworth Mfg. Co.

New York Boston Chicago

ONE of the largest collections of engineering literature in the world is the Engineering Library in the Engineering Societies Building, 29 West 39th Street, New York.

It comprises 65,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 800 technical journals and magazines are regularly received, including every important engineering journal in the world in the mechanical, electrical and mining fields.

The library is open from 9 a.m to 10 p.m., with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

THE LUDLOW VALVE MFG. CO.

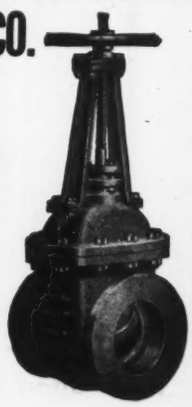
TROY, N. Y.

GATE VALVES FOR

HIGH PRESSURE STEAM

Also Water, Oil, Natural Gas, Ammonia

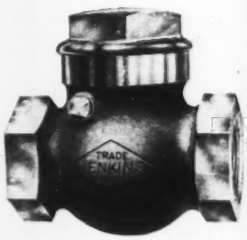
FIRE HYDRANTS, SLUICE GATES



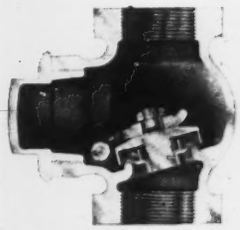
BRANCH OFFICES
New York, 62 Gold St.
Boston, Oliver Bldg.
Chicago, The Rookery
Philadelphia, Harrison Bldg.
Pittsburg, First Nat. Bank Bldg.
Kansas City, Victor Bldg.

Jenkins Bros.

Swing Check Valves
Extra Heavy Pattern



In Horizontal Position



In Vertical Position

Specially designed to meet the requirements of high pressure service.

Fitted with Jenkins Disc, ensuring perfect tightness and long service with but little repair expense.

The disc-holder and all working parts are heavy and strong. So constructed that the hanger cannot bind, nor any of the parts work loose.

Can be installed in either horizontal or vertical position.

Brass valves in sizes ½ to 3 inches; iron body and cast steel, 2 to 8 inches, inclusive. The brass valves suitable for all pressures up to 300 pounds; iron body valves, 250 pounds; cast steel, with monel metal discs and seat rings, 350 pounds.

The No. 20 Jenkins Bros. Catalogue will be mailed on request

See A. S. M. E. Catalogue

TRADE JENKINS MARK Jenkins Bros.

Jenkins Bros.

60 White Street, New York 524 Atlantic Avenue, Boston
133 N. 7th Street, Philadelphia 300 W Lake Street, Chicago
Jenkins Bros. Limited Montreal, Canada, and London E. C. England.

TRADE JENKINS MARK Jenkins Bros.

UNIVERSAL PIPE

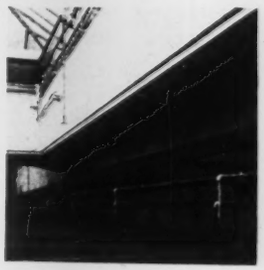
CAST IRON

CENTRAL FOUNDRY COMPANY

90 WEST STREET, NEW YORK

Chicago Dallas Atlanta San Francisco

Replaces Wrought Iron and Steel Pipe in Public Bath Houses



Universal Cast Iron Pipe—2 in. Hot and Cold Water Feed Lines.

Wrought Iron and Steel Pipe failed in less than six years.

Municipal Bath House, City of New York.

AFTER much experimenting with pipe in its municipal bath houses, the City of New York has chosen UNIVERSAL PIPE.

Universal Pipe is cast iron (cast iron pipe lasts for centuries). The Universal Joint, too, is cast iron, for 'pipe' and 'joint' are 'one'—**no lead, no pouring, no packing.**

Used for all classes of work—in the building—under the ground—UNIVERSAL PIPE has an unequalled record for low cost installation and uninterrupted service. Two wrenches the only tools.

Approved by the Underwriters' Laboratories which are under the direction of the National Board of Fire Underwriters.

See A. S. M. E. Catalogue; or Sweet's Catalogue Engineering Edition; or send for Catalogue U-B and descriptive booklets.

THE UNIVERSAL PIPE JOINT

U-171

Around Central Stations

THE long life of Cast Iron Pipe is becoming so fully recognized by power-plant engineers everywhere that its use in such plants is very rapidly increasing.

The character of the material lends itself readily to any form in casting, from straight pipe to the most intricate of special fittings.

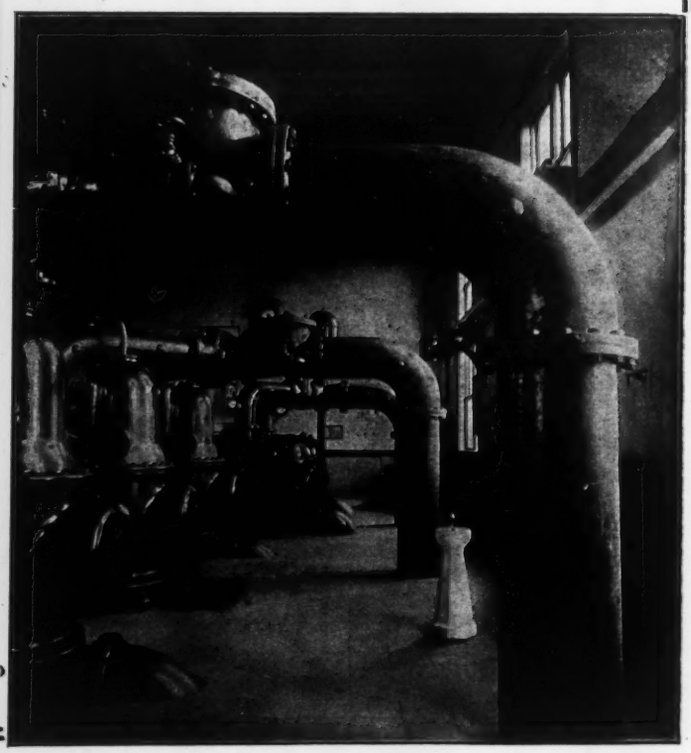
In whatever form or for whatever purpose it is used, Cast Iron possesses, always, the same qualities of "everlastingness."

THE FIRST CAST IRON PIPE EVER MADE IN THE WORLD'S HISTORY IS STILL IN SERVICE
SERVICE
CAST IRON PIPE
MEASURED BY
CAST IRON PIPE
CENTURIES
MORE THAN 250 YEARS OLD

The Cast Iron Pipe Publicity Bureau

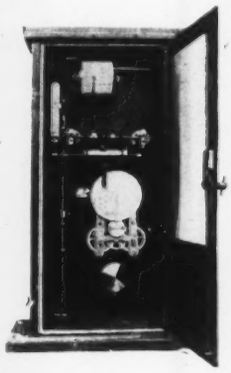
R. C. McWANE, Secretary

1 Broadway New York



CRANE 250
CRANITE
CRANITE
CRANITE

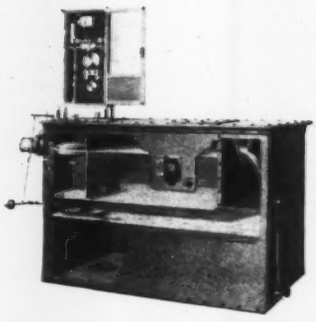
How Guaranteed Accuracy in Metering Feed Water is Assured



THE remarkable accuracy of the "Lea" V-Notch Recording Liquid Meter (guaranteed within 1½%) is the direct result of certain features which can be duplicated in no other apparatus.

The water-flow over a V-Notch is measured by a float (in a still water chamber) to which is attached a vertical spindle. This spindle is geared to and revolves a drum, upon which is a "curve of flow" screw thread. Engaging this thread is a pin actuating a sliding bar, upon which is fixed a recording pen in contact with a paper chart mounted on a clock-driven arm, revolving once in 24 hours.

The addition of a "Lea" clock-driven integrator obviates the need of planimetering these 24-hour charts, and supplies a continuous record of the exact amount of feed water used over any period of the day or night.



Among other exclusive "Lea" advantages are: 1st, a graduated vertical scale on which is indicated the exact head of water flowing over the V-Notch; 2nd, a positive, mechanically correct rack and pinion transmission between recorder float and cam drum; 3rd, a graduated cam drum so the observer may ascertain the flow of water in pounds at a glance. These features assure accurate records under all conditions of service.

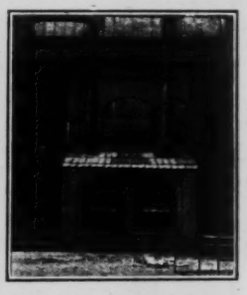
—And the value of any metering device is in direct proportion to its accuracy.

Our engineers are at your service to help decide how economical a "Lea" should be in your own plant. Write us outlining your conditions. This does not place you under the slightest obligation.

Yarnall-Waring Company
7612-20 Queen St., Chestnut Hill, Philadelphia

ANY POSITION FOR THE METER TUBE

The Venturi Meter Tube can be installed vertically, horizontally or at any angle and either above or below the indicating or recording instrument.



Meter Tubes Measuring Cooling Water, Pittsburgh Crucible Steel Co.

Venturi Meters

aid in determining boiler economy, pump efficiency, economical brine distribution, efficiency of operation of filtration plants and sewage plants Bulletin No. 84-M. and No. 85-M. give complete information. Write.

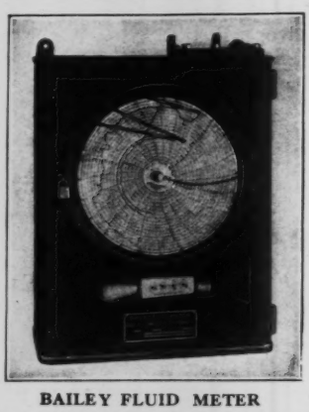
BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.

"Builders of the Venturi"
New York, Pittsburgh, Chicago, San Francisco, Los Angeles, Portland, Seattle

ONE of the largest collections of engineering literature in the world is the Engineering Library in the Engineering Societies Building, 29 West 39th Street, New York.

It comprises 65,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 1000 technical journals and magazines are regularly received, including practically every important engineering journal in the world in the mechanical, electrical and mining fields.

The library is open from 9 a. m. to 10 p. m., with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.



BAILEY FLUID METER

BAILEY FLUID METERS

read direct in thousand pound units on a uniformly graduated chart. The integrator has an even multiplier of one thousand, so that the operating engineer knows the rate of flow without resorting to factors. Recent installations of Bailey Meters include high pressure steam flowing through 16" lines, up to 250,000 lbs. of steam per hour and exhaust steam flowing through 24" pipes.

The orifice used to obtain the pressure difference is held between a pair of flanges like an ordinary gasket so that no change in piping is required. The orifice is made of Monel Metal and maintains its accuracy indefinitely under the most severe operating conditions.

Write for Bulletin No. 5 and other literature.

BAILEY METER CO., 141 Milk St., Boston, Mass.

Use Our Data 1910 A. S. M. E. Condensed Catalogues of Mechanical Equipment

Best by Test—

Is what Precision Dead Beat Gauges are granted to be by the leading Engineers today.

Put them on your gauge board in either the single types—or the 3 in 1, if you use Forced Draft.

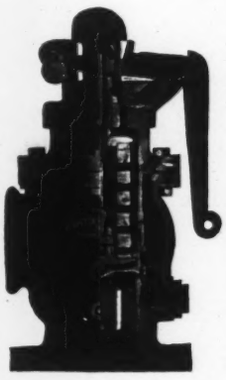
Let us tell you more about them.

Precision Instrument Company

Engineers

Detroit **Michigan**

Precision 3 in 1 Gauge



Ashton Pop Safety and Relief Valves

Pressure and Vacuum Registering and Recording

GAGES

Dependable in Quality and Service with an enviable record of over 40 years.

The Ashton Valve Co.

Boston New York Chicago

DRAFT, PRESSURE RECORDERS

GAS METERS

FOR

STEEL, COKE, GAS PLANTS

ETC., ETC.

Write for Catalogue C

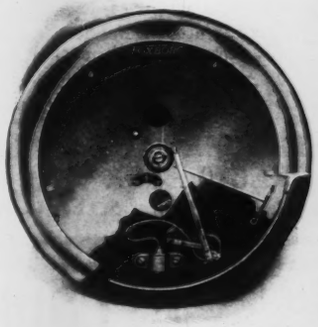
Bacharach Industrial Instrument Co.

14 Wood Street Pittsburgh, Pa.

FOXBORO

TRADE MARK

Simplicity



We illustrate herewith the interior construction of "Foxboro" Improved Recording Gauges and Thermometers.

No other type of instrument offers such **simplicity** and at the same time so many marked improvements. Here are a few of them, all sound arguments in favor of

"Foxboro" Recorders

Supported Helical Tube actuating movement; No Multiplying Levers; Absolutely Dead Beat.
Automatic Self Centering Chart Holder.
Automatic Release Pin Lifter.
Micrometer Adjustment on Pen Arm.
Special Design Clock three point support, adjustable through dust tight box.
Non-Corrosive throughout.
All parts interchangeable.
All types supplied in Round Form Case.

Write today for Bulletin No. AO-96, stating what you are interested in.

THE FOXBORO CO.

Foxboro, Mass., U. S. A.

New York Chicago Pittsburgh
Birmingham St. Louis San Francisco

THE Art of Electrical Measurement, its perfection and its growth, have been associated inseparably with this name—

Weston

From the year 1888 to now, each successive instrument that has borne the name has marked the highest achievement in the Art.

At no time has Weston superiority been more obvious than in the present models.

Weston Indicating instruments include a great variety of groups for portable or switchboard service on A. C. or D. C. Circuits, Instruments designed expressly for testing and laboratory use, for motor car and boat electrical systems, and many others for special purposes. Write for Bulletins or Catalogs describing those which interest you.

Model 280
Triple Range Volt-Ammeter

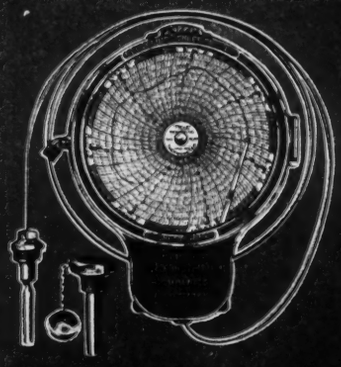
The Weston Miniature Precision Instruments are masterpieces of electrical and mechanical workmanship. They are accurate, dead-beat, extremely sensitive, effectively shielded and legible.

The group includes Voltmeters, Ammeters and Volt-Ammeters, both portable and switchboard, of various models and ranges which offer a selection from over 300 different combinations. Battery Testers are also included.

Weston Electrical Instrument Co.
49 Weston Avenue Newark, N. J.
23 Branch Offices in the Larger Cities

Use Our Data 1918 A.S.M.E. Condensed Catalogues of Mechanical Equipment

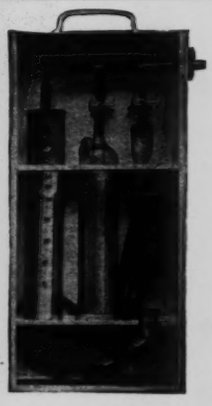
The Recording Thermometer



Past
Present
Future

A Catalog Cheerfully Sent Upon Application

The H&M Division
Taylor Instrument Companies
Rochester, N.Y.



DEFENDER
Combustion Appliances

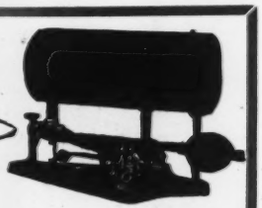
will enable you to obtain the highest furnace and boiler efficiency and to have a complete record for checking what actually is happening.

We illustrate Defender single chamber Orsat, (pinch cocks) for reading CO_2. Price $18.50.

Descriptive Bulletins free upon request

DEFENDER AUTOMATIC REGULATOR CO.
6th & Locusts Sts. St. Louis, Mo.

Morehead
~~Back to Boiler~~
SYSTEM



For Feeding Boilers

Returns the condensation with its *full* heat content direct to boilers—*and without pumps.* Every steam user needs the *Morehead System.* Can be used with any kind of service.

Get complete information from our Engineers. Write today.

MOREHEAD MFG. CO. Department 7 DETROIT, MICH.

164

Veeder **Set Back and Locked Wheel COUNTERS**

are absolutely reliable instruments for the recording of output from machines.

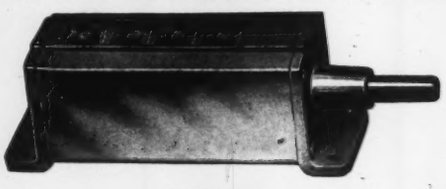
In their design special attention has been given to making an instrument which will operate with the greatest ease. They are furnished with the following forms of driving mechanism: Revolution, Direct Drive and Rotary Ratchet.

Complete catalogues showing over 25 different styles of counters mailed free upon request

THE VEEDER MFG. CO., Hartford, Conn.
16 Sargeant St.

Use Our Data 1918 A.S.M.E. Condensed Catalogues of Mechanical Equipment

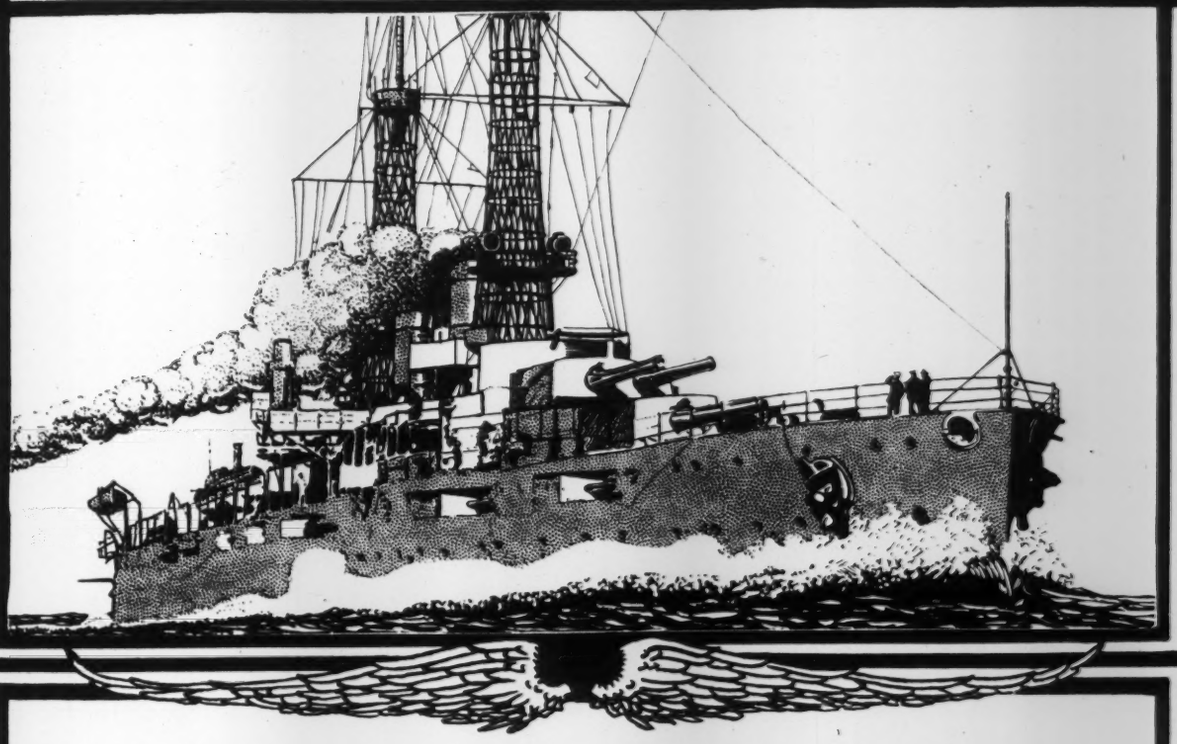
Makers of Cyclometers, Odometers, Tachometers, Tachodometers, Counters and Small Die Castings.



(Cut Half Size)

The "Locked Wheel" Counter, illustrated above, is similar to the Setback Counter except the number wheels are locked in all positions.

Especially useful where the work is paid for by the piece, as it may be connected up so the figures cannot be moved except by running the machine.



TO any of us the dreadnaught plowing its way through the waves, is always an inspiring sight.

But to the engineer it means even more—he knows something about the size and power of the engines and turbines, something of the high efficiency achieved in the Navy, and something of the difficulties encountered in operating this floating fortress under the rigors of high speed and the additional stress and strain due to the pitch and toss of the vessel.

We of The Texas Company have special reason for pride in our efficient battleships.

For years we have been supplying the lubricants which keep engines and turbines and other machinery operating smoothly, efficiently and economically. TEXACO LUBRICANTS are used throughout the Service from the newest and largest first class ships to the little patrol boats, including also destroyers, colliers, submarines and Naval aeroplanes.

The service of the oils themselves is complemented by our excellent delivery service. The same service we render to Uncle Sam is available to any of his nephews on land or sea.

There is a TEXACO LUBRICANT for every purpose.

Write for our magazine, "LUBRICATION." The October issue contains a valuable and instructive article on "Testing Lubricants for the Navy" written by Lieut. J. L. Kauffman, of the U. S. Navy.

"LUBRICATION" is a magazine devoted to the dissemination of information on lubricating problems in general, and results due to Texaco Lubricants in particular. You should have it." Write for it.

THE TEXAS COMPANY

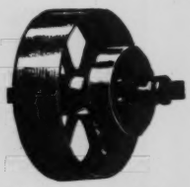
Dept. "M. E.," 17 Battery Place, N. Y. C.

HOUSTON CHICAGO NEW YORK

OFFICES IN PRINCIPAL CITIES

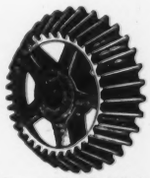
THE A. & F. BROWN CO.

ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS



Friction Clutch Pulleys and Couplings

POWER TRANSMISSION MACHINERY
DESIGNED, FURNISHED AND ERECTED



Gears of all kinds and sizes

SPECIAL MACHINERY

IRON CASTINGS

WORKS: ELIZABETHPORT
NEW JERSEY

SALES ROOM: 79 BARCLAY ST.
NEW YORK CITY

HILL FRICTION CLUTCHES
—AND—
POWER TRANSMISSION MACHINERY

The Hill Friction Clutch as built today —our New Smith Type—is the result of twenty-seven years' experience.

The keynote of our improved design and construction is mechanical stability.

• • •

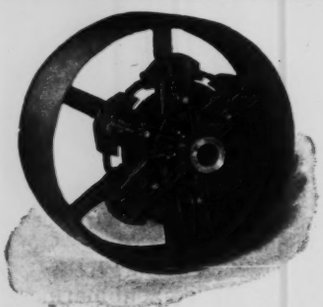
The Hill Clutch Co.
CLEVELAND OHIO

Complete Power Transmission Machinery Equipments including the Well Known *Hill Collar Oiling Bearings*

Modern and Approved Appliances for the Transmission of Power

SHAFTING HANGERS
COUPLINGS PULLEYS
COLLARS BELT TIGHTENERS
FRICTION CLUTCHES
ROPE DRIVE EQUIPMENTS

T. B. WOOD'S SONS CO.
CHAMBERSBURG, PA.



6-Arm Friction Clutch Pulley

Power Transmission Appliances

FOR

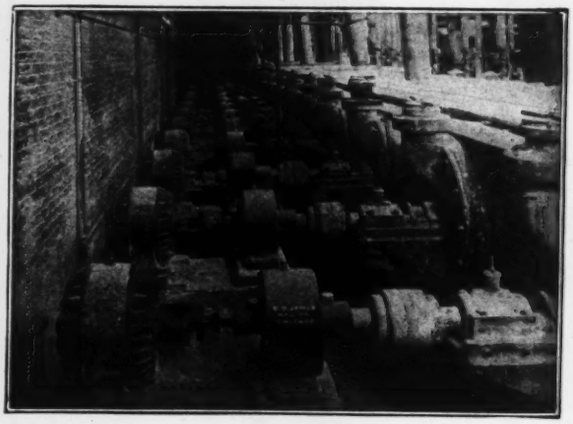
BELT AND ROPE DISTRIBUTION

Mechanical, Economical, Efficient

Friction Clutch Pulleys
Friction Clutch Couplings
Friction Clutch Operators
Head Shaft Hangers
Sheaves
Hangers and Pillow Blocks
Pulleys and Fly Wheels
Shaft Couplings
Floor Stands
Tension Carriages
Forged and Turned Shafts, etc., etc.

FALLS CLUTCH & MACHINERY COMPANY
CUYAHOGA FALLS, OHIO

Branches
NEW YORK CITY 206 Fulton St.
BOSTON, MASS. 84 Purchase St.
CINCINNATI, O., 208 Elm St.

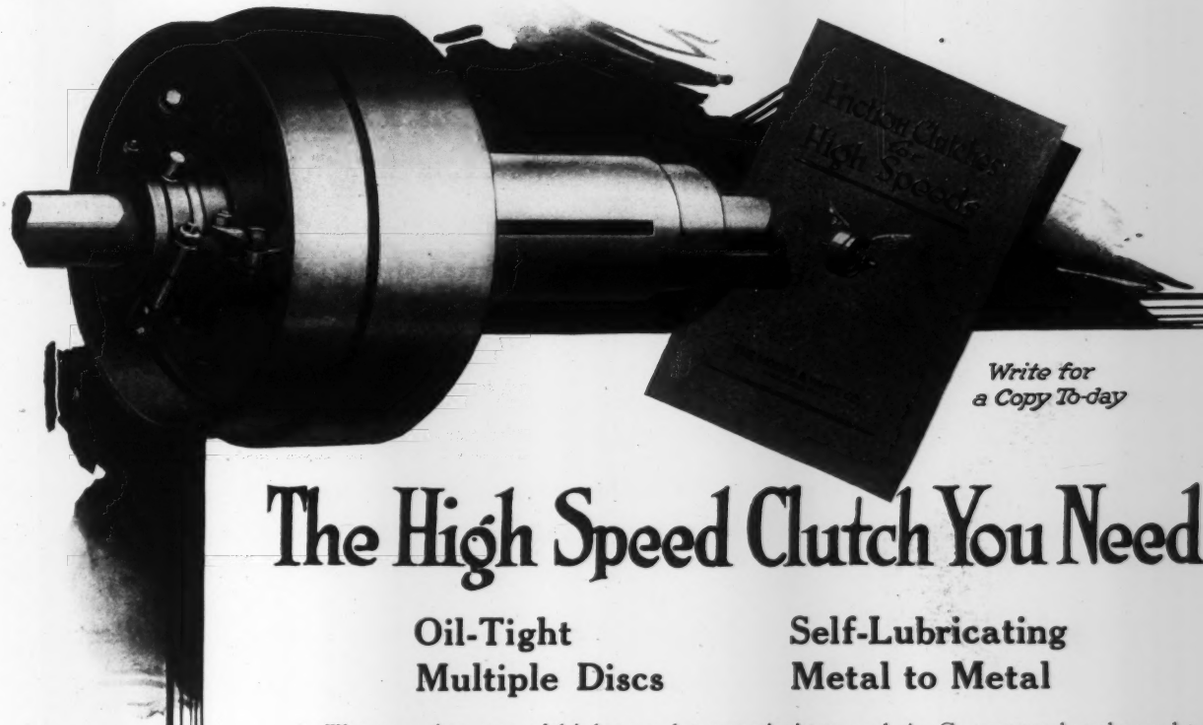


USE
JAMES SPEED REDUCERS
For Efficient Speed Reduction

No open or exposed gearing; all the mechanism totally enclosed, therefore, no dust, grit, or foreign substances admitted. No danger to workmen. Made in ratios 4:1 up to 1600:1. 1 H.P. up to 100 H.P.
A well balanced drive of great emergency strength, now doing good work in many plants. Perfectly adapted to numerous other industries:—Steel, Paper, Textile, Flour and Rubber Mills, Brick Yards, Mining Plants, and wherever else it is necessary to reduce the speed of electric motors.

Bulletin No. 5, carefully illustrated and written, gladly sent on request. Let us send you a copy at once.

D. O. James Mfg. Co., 1122 W. Monroe St., Chicago, Ill.
Specialists in Cut Gearing



Write for a Copy To-day

The High Speed Clutch You Need

Oil-Tight Multiple Discs **Self-Lubricating Metal to Metal**

The growing use of high speed transmissions and A. C. motors has brought a demand for a friction clutch able to withstand this exacting service. The Moore & White High Speed Clutch is especially designed to meet it.

Discs are bronze to cast iron, oiled but not flooded. Outer shell and adjusting ring are of steel for the higher speeds. There is no drag when released.

In the Pulley Type, the pulley is keyed to a sleeve journaled on a divided bronze bushing keyed to the shaft. Oil is held in the space between the halves of the bushing, and is fed to the sleeve by gravity and centrifugal force. Oil throwing is prevented by a retaining ring screwed to the end of the sleeve. Reoiling is seldom needed.

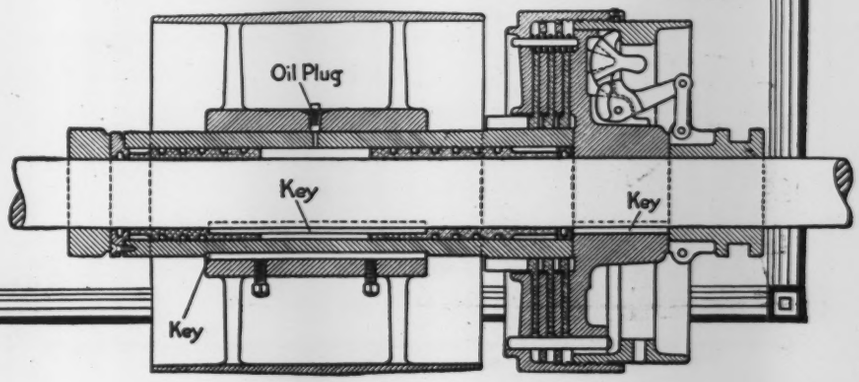
Two types—Pulley and Cut-Off Coupling. Seven sizes, from 5 to 25 inches disc diameter, each with 1 to 6 bronze discs, according to power. Speeds to 3000 R.P.M. for smallest size. Power to 630 H.P. for largest size.

Many of these clutches are now in use on A. C. electric motors, high speed group drives and individual high speed machines, and have proved their endurance under the severest conditions. We will gladly advise about special applications. Write for Catalog "D."

THE MOORE & WHITE COMPANY

2713 to 2743 N. 15th St., Philadelphia, Penna.

Makers also of the Moore & White Variable Speed Change for Paper Mills, Textile Machinery, Dryers, Conveyors, Boring Mills and Lathes, Cement Kilns, etc.



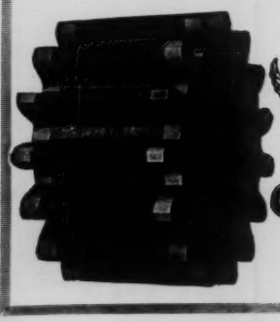
Rawhide is to quiet gear driving what copper is to electricity

But full benefits and ***lastingly*** good service from rawhide can be obtained only from ***selected*** parts of ***selected*** hide stock, cured, compressed and machined under conditions which avoid every uncertainty and variation.

We originated and control the process which brought rawhide to supremacy for quiet gear work and have maintained New Process Pinions at top-notch efficiency and economy.

You only cheat yourself by accepting a substitute or being satisfied with noisy destructive metal pinions when the use of New Process Pinions would assure ***permanently*** smooth, quiet power delivery.

Ask for our book "Noiseless Gear Driving"



N.P.R.H. REG. U.S. PAT. OFF.

NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

NEW PROCESS GEAR CORPORATION

SYRACUSE, N. Y.

Canadian Agents: Robert Gardner & Son, Ltd., Montreal

GILMER REG. U.S. PAT. OFF. = Efficiency, Speed, Service, Satisfaction

Gilmer Belts run **true** with **constant** speed and **without** vibration.

They permit of more and better work.

They insure maximum efficiency of high speed machines.

They increase life of machine itself.

The per hour cost on Gilmer Belts is less than any belt made.

We want you to try them in the **hardest place in your plant.**

L. H. GILMER CO.

Belt Department

Philadelphia, Pa., U. S. A.

The Sign of Service

"The Ahlberg Bearing Company guarantees Ahlberg Reground Bearings are as good or better than new bearings."

And here are the reasons

Materials

All rings are time and wear tested. All balls are new. All retainers are new.

Care

All rings are three times inspected. All balls are twice inspected and micrometer measured for size and uniformity. All rings are measured for size and unusual wear. Every bearing is inspected six times before final acceptance.

Skill

All raceways are reground and polished by Ahlberg Grinding Machines. We are the patentees. Ahlberg retainers used. They were invented to overcome the defects we observed in thousands of other retainers as they came to us. All rings measured by Ahlberg invented measuring instruments.

Call at our nearest branch and see the finished product. You will agree that we live up to the utmost demanded by our guarantee.

For Quickest Service See Our Nearest Branch

ST. LOUIS, 2831 Locust St. MINNEAPOLIS, 926 Marquette Ave. CLEVELAND, 1836 Euclid Ave. ATLANTA, 323 Peachtree St.

LOS ANGELES, 325 W. Pico St. SAN FRANCISCO, 715 Turk St.

DETROIT, 790 Woodward Ave. NEW YORK, 1790 Broadway BOSTON, 93 Massachusetts Ave. PORTLAND, 325 Davis St.

Ahlberg Bearing Company

2636 Michigan Avenue **Chicago, Ill.**

MACHINERY builders of notably high repute use "NORMA" Bearings in their high-speed apparatus because they have proved that "NORMA" silence, speedability and serviceability give them the best protection against the criticism of their designs which would come with bearing troubles.

Let us send the catalog

THE NORMA COMPANY OF AMERICA

1790 BROADWAY NEW YORK

Ball, Roller, Thrust, Combination Bearings

INCREASE YOUR WIRE ROPE EFFICIENCY

BY USING

Roebling Wire Rope

Standard for

Mining
Logging
Dredging
Elevators
Tramways
Cableways
Incline Haulage
Power Transmission
Ferries
Oil Wells
Quarrying
Construction
Switching and Wrecking
Rigging
Suspension Bridges
and all other purposes

Roebling Blue Center Steel Rope

under those conditions where a high strength, tough wire rope is required. It is made of our Blue Center Steel, subjected to the most careful tests in manufacture and possesses unexcelled wear-resisting qualities. Accepted as the economic rope because of its high efficiency.

Wire Rope Fittings

Hooks—Clamps—Clips—Sockets—Turnbuckles—Sheaves

WRITE FOR CATALOGUE

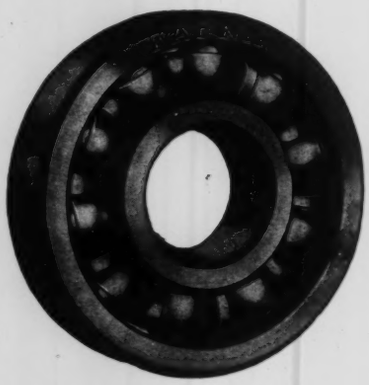
JOHN A. ROEBLING'S SONS CO.

TRENTON, NEW JERSEY

FAFNIR
Ball Bearings

Where efficiency, service and endurance are demanded features in the performance of your machine, it will be well to investigate the Ball Bearing question thoroughly and let us tell you why

Fafnir Quality Is Best



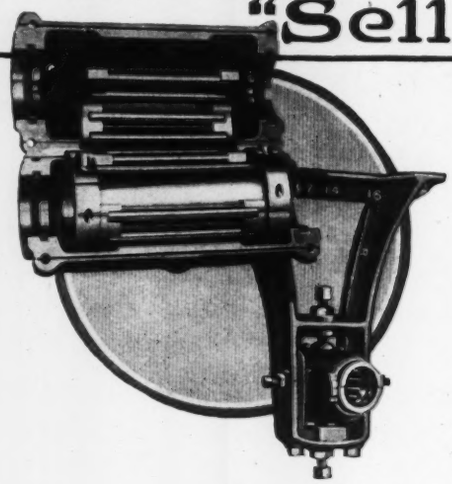
THE FAFNIR BEARING COMPANY

CONRAD PATENT LICENSEE

MAIN OFFICE AND FACTORY:
NEW BRITAIN, CONN.

DETROIT OFFICE: - 752 DAVID WHITNEY BUILDING
CHICAGO OFFICE: - - 39 SOUTH CLINTON STREET

"Old Reliable" "Sells".



There are just four reasons which have given "SELLS" ROLLER BEARINGS their phenomenal sales impetus:

—they fit practically every standard hanger, without necessitating changes in hanger or bearing.

—they can easily be installed over night—so their installation does not interfere with shop operations.

—they never wear the shaft—because they are the only roller bearings on the market which are supplied with a hardened shaft-protecting split-sleeve on which the rollers operate.

—they are ordered repeatedly in constantly increasing quantities by the very largest and foremost manufacturers in the country—a list of whose names and the quantities of whose purchases we will gladly send you on request.

John D. Sells
Manager.

Royersford Foundry & Machine Co.
60 North 5th Street, Philadelphia

Babbitted Ring Oil Bearings—Shaft Hangers, Collars and Couplings—Punches and Dies—Punching and Shearing Machines—Sensitive Drill Presses—Drill Presses—Foot Presses—Grinding and Polishing Machines—Tumbling Barrels—"Rollerine," the ball and roller bearing lubricant.

1918 A. S. M. E. Condensed Catalogue of Mechanical Equipment

Minimize transportation costs from ore bin to tailings pile

Five miles of the best belt that our 47 years of experience can make leaves the Goodrich factories every day. This belt goes to mills, mines, railroads and manufacturing plants of every description.

Operating conditions are seldom if ever alike, even in allied industries, and yet users of "Longlife" in all industries report low cost and greater tonnage.

The significant point is this: That Goodrich Belts are made from years of practice, not from theory, and they overcome varying conditions because of our familiarity with those conditions.

From ore bin to tailings pile, on horizontal or incline conveyors, Goodrich Belts operate with fewer shutdowns and establish enormous tonnage records.

Ask for catalog. "Goodrich Rubber Goods For Mines."

THE B. F. GOODRICH COMPANY

Makers of the Celebrated Goodrich Automobile Tires—*"Best in the Long Run."*

Factories: Akron, Ohio. Branches and Distributors in All Districts.

HANDLING 1500 PACKAGES PER HOUR

From Shipping Room to Vessel—with

JEFFREY PORTABLE SECTIONAL BELT CONVEYOR

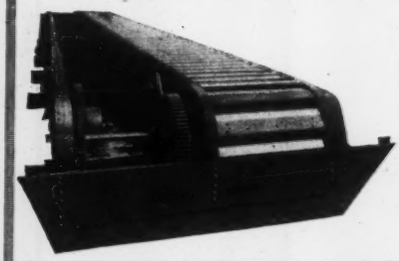
Conveyor is built in seven sections of 20 feet each, with Belt 18 inches wide, 80 lb. packages being spaced 5 feet apart. Motor and Gearing for driving can be placed in the clear beneath the belt, and Drive Section may be placed at either end or at intermediate points, as desired. A 5 H. P. Motor drives the entire conveyor.
These Conveyors are built in any consistent lengths or widths for the handling of Bags, Boxes, etc.

Send full details of your handling problem, and ask for copy of Portable Conveyor Bulletin No. 184-4

The Jeffrey Mfg. Co., 904 North Fourth Street, Columbus, O.

New York Philadelphia Chicago St. Louis Milwaukee
Montreal Boston Pittsburgh Birmingham Denver
Seattle Dallas

CALDWELL CONVEYORS



Belt Conveyors
Pan Conveyors
Apron Conveyors
Screw Conveyors
Scraper Conveyors
Cable Conveyors

H. W. CALDWELL & SON CO.

Elevating, Conveying and Power Transmitting Machinery
CHICAGO, - - 17th St. and Western Ave.
NEW YORK, - - - - 50 Church St.
DALLAS, TEXAS, - - - - 711 Main St.

The Eastern Machinery Co.

NEW HAVEN, CONN.

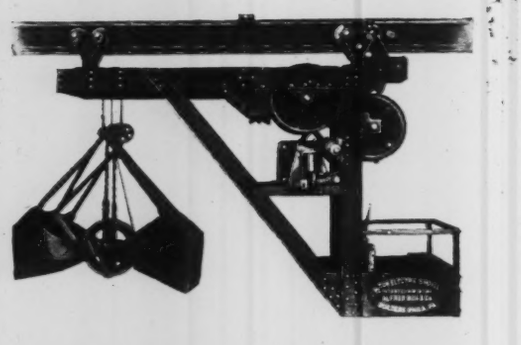
MANUFACTURERS OF

Electric and Belt Power Passenger and Freight Elevators

Hoisting Machines, Friction Winding Drums

Friction Clutches and Friction Clutch Pulleys

CRANES



FOR EVERY SERVICE

ALFRED BOX & CO.

PHILADELPHIA, PA.

ONE of the largest collections of engineering literature in the world is the Engineering Library in the Engineering Societies Building, 29 West 39th Street, New York.

It comprises 65,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 800 technical journals and magazines are regularly received, including every important engineering journal in the world in the mechanical, electrical and mining fields.

The library is open from 9 a.m. to 10 p.m., with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

The Morgan Engineering Co.

ALLIANCE, OHIO

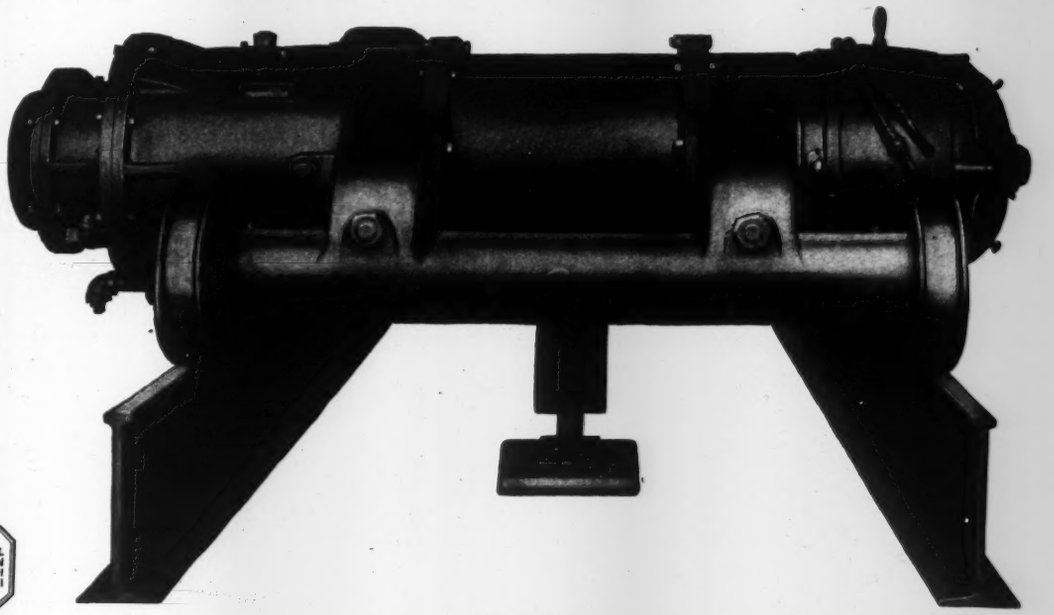
Largest Builders of

Electric Traveling Cranes

in the World

We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

SHEPARD ELECTRIC CRANE & HOIST COMPANY



Form 6

Fully enclosed gearing, oil bath lubrication throughout. Absolute alignment of gearing under all conditions.

Montreal, Rudel-Belnap, Ltd. | Main Office & Works | Birmingham, Shook & Fletcher Co.
San Francisco, Berger & Carter Co. | Montour Falls, N. Y. | London, England, W. Baylis, Ltd.

HUDSON TERMINAL BLDG. NEW YORK | **STEPHEN GIRARD BLDG. PHILADELPHIA** | **MACHESNEY BLDG. PITTSBURG** | **PEOPLES GAS BLDG. CHICAGO**

"Of Distinctively Superior Design and Workmanship"

NORTHERN CRANES

The "Repeat-Order" Kind

The Northern "Type E" Electric Traveling Crane

Type E Electric Crane Trolley
"The Ideal Crane Trolley"

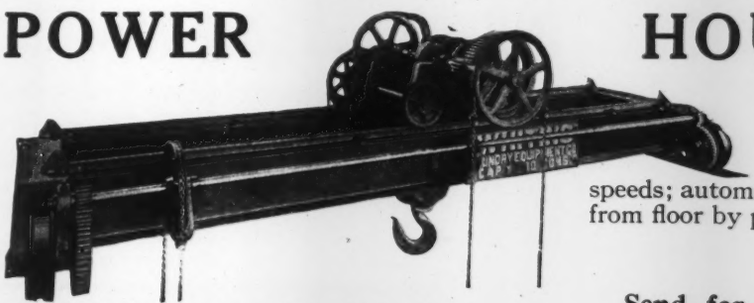
A Crane in a Superior Class by Itself. Unique in its Safety and Efficiency Features. Let us send catalog

DIMENSION DIAGRAMS, WHEEL LOADS, ETC., ON REQUEST

Electric and Hand Cranes of All Types, Electric Hoists, Monorail Systems, Foundry Equipment, etc.

NORTHERN ENGINEERING WORKS, Detroit, Mich., U. S. A.

POWER HOUSE CRANES



Our "Rope - Drum Hoist" crane illustrated here is especially useful in power houses, a large number being in service today. Two speeds; automatic brake; all movements operated from floor by pendant chains.

Complete Foundry Equipments
CRANES OF ALL TYPES

Send for crane Catalog No. 110

WHITING FOUNDRY EQUIPMENT CO HARVEY ILL U S A

The Position of the Operator

cannot be improved either for firing the boiler or view of the load and is entirely unobstructed by piping, boom latticing or other obstructions. Another evidence that the designs of

O. S. LOCOMOTIVE CRANES

are the most "up-to-date" on the market and are the result of many years of experience in the design, manufacture and operation of such equipment.

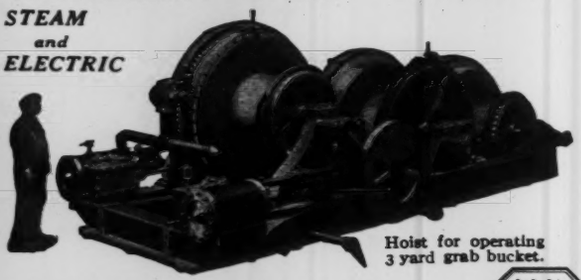
They have been made the standard of many large railroads and other corporations and their popularity is evidenced by a demand for them which has always taxed our producing capacity to the utmost.

ORTON & STEINBRENNER CO.

Main Office: CHICAGO, ILL. **Works: HUNTINGDON, IND.**

LIDGERWOOD HOISTS

STEAM and ELECTRIC



Hoist for operating 3 yard grab bucket.

Strength, Safety, Service. More than 37,000 Steam and Electric Hoists built and used

Lidgerwood Mfg. Co. 96 LIBERTY ST. NEW YORK

Sprague Electric

1/4 Ton Hoist

For Lifting Light Loads

Send for Bulletin No. I-60

SPRAGUE ELECTRIC WORKS
OF GENERAL ELECTRIC COMPANY
Main Offices: 527-531 W. 34th St., New York, N. Y.
Branch Offices in Principal Cities

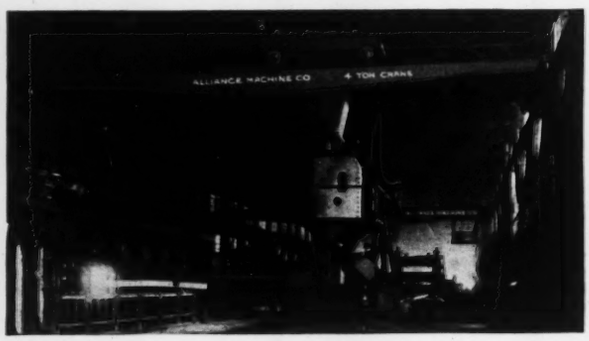
1500 yds a Day: Two Canal Jobs - No Trouble

This is what T. H. Brockman, general superintendent of a New Orleans contracting firm says of his Full-Swing Excavator. This plant operates a 1⅝ cubic yards clamshell bucket and is equipped with a double-drum hoisting engine bearing the trade-mark

CLYDE

Mr. Brockman says this machine has accomplished $500,000 worth of work, has cost practically nothing for up-keep—and is still going strong. He is another ardent booster for the products of the

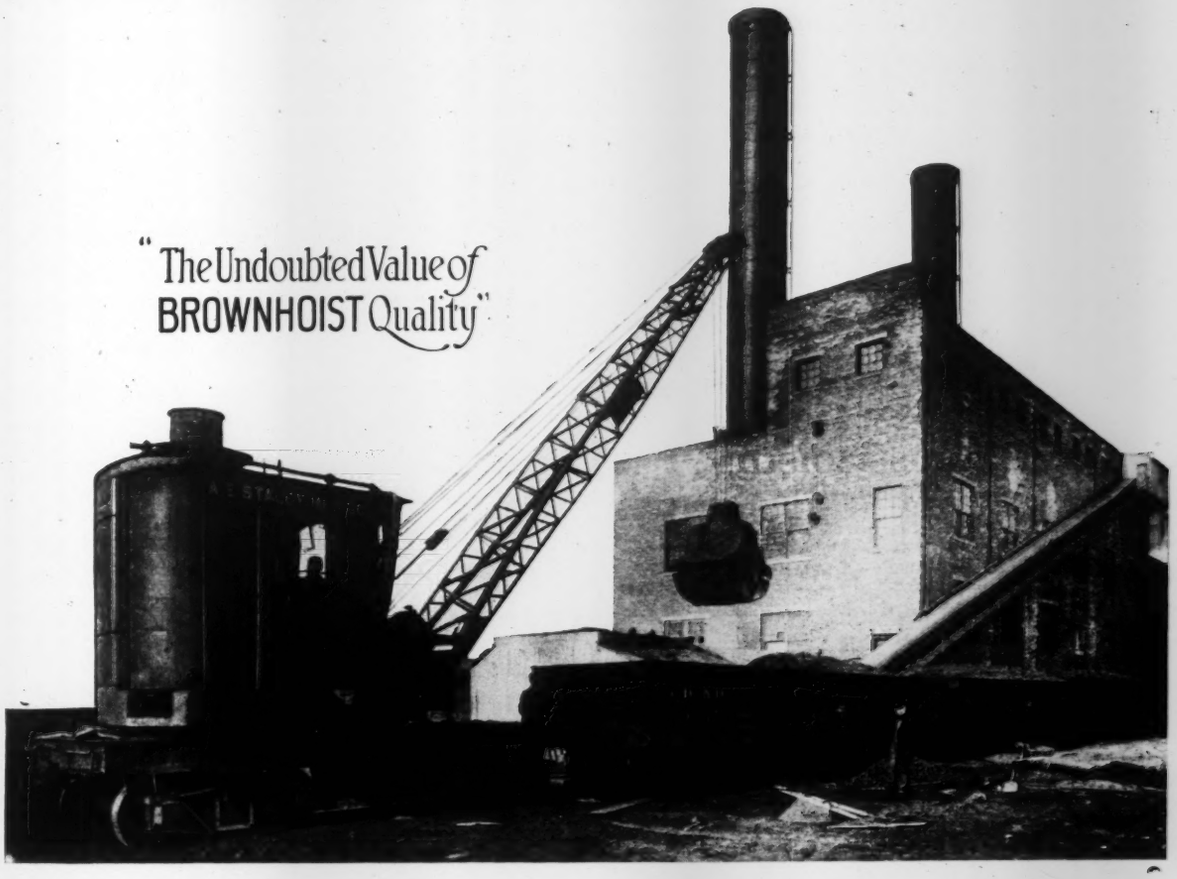
CLYDE IRON WORKS
DULUTH, MINN.



Economical *Durable*

"ALLIANCE" Crane Type
Billet Charging Machine

Cut shows a machine designed to charge billets and slabs into and draw them from reheating furnaces. It will pick up a slab from any position on the floor and chargeit into the furnace.



BROWNHOIST CRANES

May Cost More—
But Are Worth It

Records Prove This

"We believe you to be one of the few concerns who consider the moral obligations of a contract as obligatory as though formally drafted in the written instrument.

"We are pleased to take this means of expressing our high satisfaction at the work you have done for us, and our experience will certainly compel us in the future to take into consideration when placing contracts, the undoubted value of 'Brownhoist Quality,' which is something entirely tangible, though it cannot be covered in many cases by the most rigid specifications."

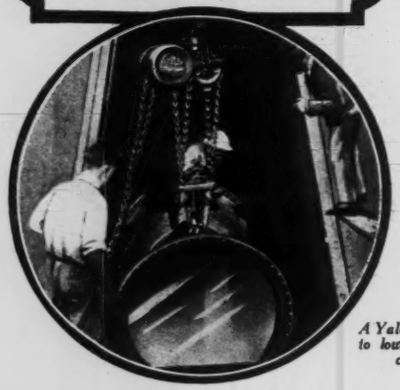
(Extract from letter received from a user of a Brownhoist Crane.)

This concisely explains the many repeat orders that we receive. It can be generally stated that once a Brownhoist Crane is used, it will always be Brownhoist Cranes thereafter. In the first place, we build the cranes for hard, continuous service, and they are sure to give satisfaction. And, secondly, we work for our customers' interests as well as our own. It pays to buy Brownhoist Cranes.

WRITE FOR CATALOG I
It describes the Brownhoist Locomotive Crane, and shows how and where some of them are used on different kinds of work.

THE BROWN HOISTING MACHINERY CO.
CLEVELAND, OHIO
Engineers and Manufacturers of Cranes and Hoists
Branch offices in
New York, Pittsburgh, Chicago, San Francisco, Montreal and (Portland, Ore., Colby Engr. Co.)

YALE



A Yale Hoist ready to lower operating chamber

Hazardous Hoisting

on land or under the sea—is safe when Yale Triplex Blocks are used.

Making moving pictures on the floor of the ocean is risky business and every care must be taken to safeguard the operator and the expensive equipment.

Yale Triplex Blocks are selected for this dangerous work because of their recognized strength and reliability—the result of Yale Steel Vitals and Yale Safety features.

Forty years of study and specialization have developed the exclusive details that make Yale Chain Blocks best for every use.

For Sale by Machinery Supply Houses.

PUT YOUR HOISTING PROBLEMS UP TO US

ASK FOR NEW CATALOG.

For factory locking equipment use a Yale Master-key System. Write us for particulars.

The Yale & Towne Mfg. Co. 9 East 40th Street New York

Of course we're proud of the

Ford Tribloc CHAIN HOIST

for our customers tell us that it is safer and easier running and enables them to handle work more quickly than with any other hoist they have used. If you don't know all about it write us today. We will be glad to tell you all about it and send you a copy of our Catalog.

Write today to—

Ford Chain Block & Mfg. Company

139 Oxford Street, Philadelphia, Pa.

The Annual Meeting Number

of The Journal of the A. S. M. E. will be issued January 1st, 1917. The entire Meeting will be reported in this issue.

Advertising Forms Close Dec. 11th

The R. K. LeBlond Machine Tool Co.

CINCINNATI, OHIO

We manufacture a complete line of Heavy Duty Lathes and Milling Machines. They are scientifically designed, so the power is limited only by the strength of the cutting tool. It will pay you to investigate our machines.

Catalogue upon request

The Journal of The American Society of Mechanical Engineers

November, 1916 CARD INDEX Vol. 38, No. 11

The Progress of Economic Power Generation and Distribution. By Samuel Insull. Deals with the economic problems in connection with the business of generating and distributing electrical energy from the standpoint of the experience of the Commonwealth Edison Company..... 845

The Sales Engineer and his Relation to Production and Machine Design. By Arthur J. Baker. Shows that the sales engineer has already had a positive influence upon future design of machine tools..... 855

Annual Meeting Papers. Comprehensive abstracts of fourteen of the papers to be presented and discussed at the 37th Annual Meeting of the Society, New York, December 5–8, 1916..... 859

Correspondence. Letters on matters of current engineering interest.. 897

Works of the Boiler Code Committee. Replies to fourteen inquiries regarding interpretations of the A.S.M.E. Boiler Code..... 900

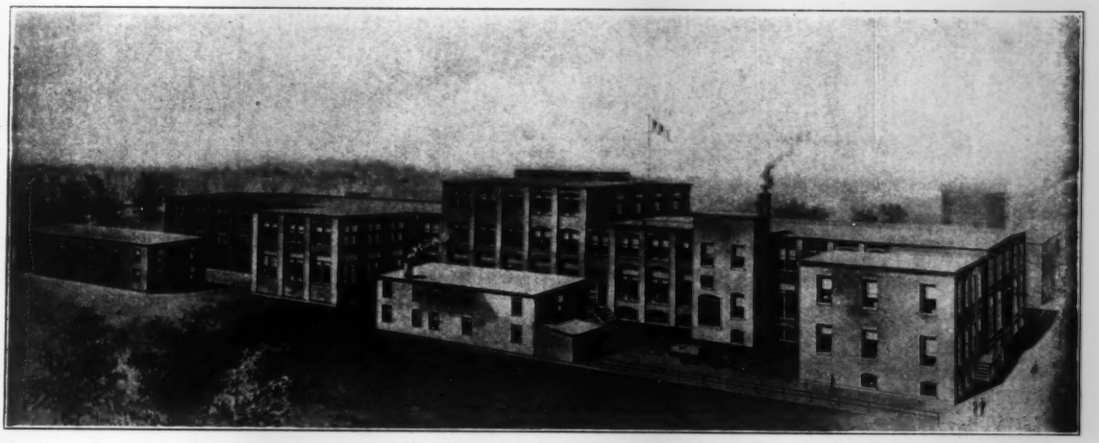
Society Affairs..... 903

Engineering Survey. Review of Engineering publications in all languages and selected titles of current engineering articles..... 927

A GENERATING Cutter hardened for staying qualities regardless of distortion, then ground to the true involute; a machine designed both as a rougher and a finisher and built around the cutter in such manner that the cutter is operated under ideal conditions: this is the Gear Shaper platform.

THE FELLOWS GEAR SHAPER CO.

Springfield, Vt.



C. H. Cowdrey Machine Works

FITCHBURG, MASS.

Contractors, Builders, and Designers of Special Machinery

"Imperial" Air Motor Hoists.
Bulletin 8006.

"Little David" Drills.
Bulletin 8407.

"Little David" Chipping Hammer.
Bulletin 8113.

CONVENIENCE IN HANDLING WORK

In a busy shop, the convenience afforded each machinist to hoist and place his heavy work is a factor in attaining maximum production. With "Imperial" Air Motor Hoists there is no call for one man to neglect his work to help handle another's.

"Imperial" Air Hoists cost but little to operate. They are compact, self oiling and easily controlled. The worm and gear mechanism is self locking at any height. The grooved drum is of ample capacity to prevent the rope overlapping and chafing.

They are built in 5 sizes, in capacities to 5 tons, for a maximum lift of 20 feet.

"Imperial" Hoists serving your machine tools will conserve your machinist's time.

Ask for details—mention Bulletin 8006.

INGERSOLL-RAND COMPANY

11 Broadway NEW YORK — *Offices the World Over* — 165 Q. Victoria St. LONDON

"Little David" Grinders.
Bulletin 8407.

"Little David" Riveting Hammers.
Bulletin 8211.

26-H

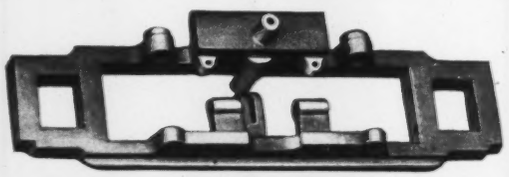
G. & B. FURNACES

FIFTY years practical experience, combined with a thorough knowledge of fuels, enters into the designing and building of Gilbert and Barker Furnaces. Our furnaces are convenient for the operator from whom they require little attention—giving a reliable and uniform heat throughout—and burning the fuel in the smallest possible space with complete combustion—they economize in time, labor up-keep and fuel.

Gilbert & Barker Mfg. Co.
Springfield, Mass.

GILBERT & BARKER MFG. CO. G&B SPRINGFIELD MASS U.S.A. EST. 1865

See that your furnaces bear this trade-mark



DOEHLER DIE-CASTINGS

are the standard of comparison in the ever-growing die-casting field. DOEHLER Quality and DOEHLER Service have attained for them this enviable position.

The fact that DOEHLER Die-Castings are extensively used by the largest and most conservative manufacturers of various machine parts is ample proof of their merit.

DOEHLER DIE-CASTING CO.
BROOKLYN. N.Y.
NEWARK. N.J. TOLEDO. OHIO.

Producers of Die-Castings in Aluminum, Zinc, Tin and Lead Alloys. Also manufacturers of Die-Cast Babbitt Bearings and Babbitt-Lined Bronze Bearings.

Just Out Catalog 37

In this New Catalog are shown all the lines now manufactured by the Greenfield Tap and Die Corporation and which have heretofore been shown separately in the catalogs of the Divisions:

Wells Brothers Co. Div. No. 34
Wiley & Russell Mfg. Co. Div. No. 36
A. J. Smart Mfg. Co. Div. No. 3

and include the following famous brands:

Little Giant—Lighting—Green River—Smart

Every need of the user of screw cutting tools will be found in this new book. Every tool is backed by our guarantee and 45 years' manufacturing experience.

Greenfield Tap and Die Corporation
GREENFIELD, MASS.

New York, 28 Warren St. Chicago, 13 So. Clinton St. Philadelphia, 38 N. 6th St.

Write to-day for G T D Catalog Number 37

Established 1850

THE DEFIANCE MACHINE WORKS
Machinery Specialists

Wishes to Announce

That in addition to their splendid facilities for the manufacture of special woodworking machinery, which have made their line famous all over the world.

They Have now Added

New departments, equipped with modern tools, together with efficient engineering staffs, especially trained and skilled for inventing, developing and building special machinery of almost any description for working wood or metal, or for other purposes, and are now prepared to take on contracts of any volume.

Promoters and Users

of special machinery are invited to submit their propositions to us with the assurance that same will be given prompt and intelligent consideration.

Governmental Work Especially Desired

We have furnished direct, practically every government of the world, equipments of special machines for military purposes.

THE DEFIANCE MACHINE WORKS
DEFIANCE, OHIO, U.S.A.

CUMBERLAND STEEL COMPANY
TURNED AND GROUND CUMBERLAND, MD.
HIGHLY POLISHED SHAFTING U.S.A.

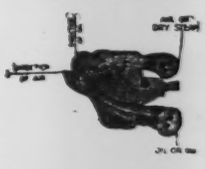
Only Makers of "CUMBERLAND GROUND" Shafting
Large Stocks **Quick Shipments**

Union Drawn Steel Co.
Beaver Falls, Pa.

MAKERS OF

Bright Cold Finished Bessemer, Open Hearth, Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

There is nothing better than the Best



To secure 100% Economy and 100% Efficiency use W. N. Best oil and tar burners and furnaces for Annealing, Case Hardening, Tempering, Forging, Heat Treating, etc.

SEND FOR CATALOG

"There is nothing better than the Best"

W. N. BEST, Inc.
11 Broadway **New York City**

CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Manufactured by Firms Represented in The Journal of The American Society of Mechanical Engineers

Accumulators, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Aerial Tramways
(See Tramways, Wire Rope)

Air Brakes, Compressors, Filters, Receivers, etc.
(See Brakes, Compressors, Filters, Receivers, etc., Air)

Air-Jet Lifts
Schutte & Koerting Co.

Air Lift Pumping Systems
* Ingersoll-Rand Co.

Air Washers
General Condenser Co.
* Spray Engineering Co.

Alternators
(See Generators, Electric)

Ammeters
* Bristol Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.
* Weston Electrical Instrument Co.

Ammonia Condensers, Fittings, etc.
(See Condensers, Fittings, etc., Ammonia)

Analytical Apparatus
Scientific Materials Co.

Anemometers
* Taylor Instruments Cos.

Anvil Blocks
Hooven, Owens, Rentschler Co.

Arches, Ignition (Flat Suspended)
* Green Engineering Co.

Asbestos Products
* Johns-Manville Co., H. W.

Ash Ejectors
(See Ejectors, Ash)

Balances and Weights
Scientific Materials Co.

Ball Bearings, Gages, etc.
(See Bearings, Gages, Ball)

Balls, Brass and Bronze
* Gwilliam Co.

Ball Bearings Reground
Ahlberg Bearing Co.

Balls, Steel
Ahlberg Bearing Co.
* Atlas Ball Co.
* Gwilliam Co.

Barrows, Furnace Charging
Weimer Machine Works Co.

Bearings, Ball
Ahlberg Bearing Co.
Fafnir Bearing Co.
* Gwilliam Co.
* Norma Co. of America

Bearings, Roller
* Gwilliam Co.
* Norma Co. of America
* Royersford Fdry. & Mch. Co.

Bearings, Self-Oiling
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Doehler Die-Casting Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Jeffrey Manufacturing Co.
* Link-Belt Co.
* Royersford Fdry. & Mch. Co.
* Wood's Sons Co., T. B.

Bearings Thrust
Ahlberg Bearing Co.
Fafnir Bearing Co.
* Gwilliam Co.
* Hill Clutch Co.
* Norma Co. of America

Bells and Hoppers, Furnace
Weimer Machine Works Co.

Belt Dressing
Quaker City Rubber Co.
* Schieren Co., Chas. A.
* Texas Co.

Belt Fasteners
* Bristol Co.
* Flexible Steel Lacing Co.
Quaker City Rubber Co.

Belt Lacing
* Schieren Co., Chas. A.

Belt Lacing (Hinge)
* Flexible Steel Lacing Co.

Belt Tighteners
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Hill Clutch Co.
* Wood's Sons Co., T. B.

Belting, Chain Link
(See Chain Belts and Links)

Belting, Conveyor
* Goodrich Co., B. F.
Quaker City Rubber Co.

Belting, Endless, Woven
* Gilmer Co., L. H.

Belting, Leather
* Schieren Co., Chas. A.

Belting, Rubber
* Goodrich Co., B. F.
Quaker City Rubber Co.

Belting, Textile
* Gilmer Co., L. H.
* Goodrich Co., B. F.

Benches, Work
Manufacturing Equipment & Engrg. Co.

Bending Machines, Hydraulic
Morgan Engineering Co.
* Wood & Co., R. D.

Blocks, Tackle
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Roebling's Sons Co., John A.

Blowers, Centrifugal
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Blowers, Pressure
* Lammert & Mann
* Roots Co., P. H. & F. M.

Blowers, Rotary
* Lammert & Mann
* Roots Co., P. H. & F. M.
Schutte & Koerting Co.

Blowers, Soot
* Diamond Power Specialty Co.

Blowers, Steam
Schutte & Koerting Co.

Blue Printing Machines
Wickes Bros.

Boiler Coverings, Furnaces, Tube Cleaners, Tubes, etc.
(See Coverings, Furnaces, Tube Cleaners, Tubes, etc., Boiler)

Boilers, Heating
* Keeler Co., E.
* Smith Co., H. B.

Boilers, Internal Furnace
* Bigelow Co.
Connelly Boiler Co., D.
* Springfield Boiler & Mfg. Co.

Boilers, Locomotive
* Bigelow Co.
* Clyde Iron Works
* Erie City Iron Works
* Lidgerwood Mfg. Co.

Boilers, Marine
* Almy Water Tube Boiler Co.
* Babcock & Wilcox Co.
* Keeler Co., E.

Boilers, Return Tubular
* Bigelow Co.
Connelly Boiler Co., D.
* Erie City Iron Works
* Keeler Co., E.
* Springfield Boiler & Mfg. Co.
* Wickes Boiler Co.

Boilers, Vertical Tubular
* Bigelow Co.
* Clyde Iron Works
* Lidgerwood Mfg. Co.

Boilers, Water Tube
* Almy Water Tube Boiler Co.
* Babcock & Wilcox Co.
* Bigelow Co.
Connelly Boiler Co., D.
* Edge Moor Iron Co.
* Erie City Iron Works
Heine Safety Boiler Co.
* Keeler Co., E.
* Springfield Boiler & Mfg. Co.
* Wickes Boiler Co.

Bolt-Cutting Machines
Greenfield Tap & Die Corp.

Boring and Turning Mills, Vertical
King Machine Tool Co.

Brake Blocks
* Johns-Manville Co., H. W.

Brass-Working Machine Tools
(See Tools, Brass Working Machine)

Breewrs' and Bottlers' Machinery
* Vilter Mfg. Co.

Bridge Tramways
(See Tramways, Bridge)

Bridges
Toledo Bridge & Crane Co.

Buckets, Elevator
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Jeffrey Manufacturing Co.
* Link-Belt Co.

Buckets, Grab
Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
* Lidgerwood Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
Whiting Foundry Equip. Co.

Buckets, Self-Dumping
Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Link-Belt Co.
Orton & Steinbrenner Co.

Bulldozers
* Wood & Co., R. D.

Burners, Gas
Weimer Machine Works Co.

Burners, Oil
* Best, W. N.
* Gilbert & Barker Mfg. Co.
Schutte & Koerting Co.
* Spray Engineering Co.

Cabinets and Tables, Blue-Print
Manufacturing Equipment & Engrg. Co.

Cable, Wire
(See Rope, Wire)

Cable Railways
(See Railways, Cable)

Cables, Electrical
(See Wire and Cables, Electrical)

Cableways, Excavating
* Lidgerwood Mfg. Co.

Cableways, Hoisting and Conveying
* Lidgerwood Mfg. Co.

Calorimeters
* Precision Instrument Co.
Sarco Co., Inc.
Scientific Materials Co.

Calorimeters, Gas, Recording
Smith Gas Engineering Co.

Car Hauls, Cable and Chain
Jeffrey Mfg. Co.
* Link-Belt Co.

Carriers and Elevators, Freight, Continuous
* Caldwell & Son Co., H. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Cars, Cinder and Hot Metal
Weimer Machine Works Co.

Cars, Dump
* Hunt Co., Inc., C. W.
Weimer Machine Works Co.

Cars, Freight Elevator
Eastern Machinery Co.

Cars, Industrial Railway
* Hunt Co., Inc., C. W.
* Link-Belt Co.
Whiting Foundry Equip. Co.

Cars, Motor
* Hunt Co., Inc., C. W.

Castings, Brass and Bronze
Crescent Mfg. Co.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.

Castings, Die-Molded
* Doehler Die-Casting Co.
* Veeder Mfg. Co.

Castings, Iron
* Brown Co., A. & F.
Buffalo Fdry. & Mch. Co.
Builders Iron Foundry
* Caldwell & Son Co., H. W.
* Central Foundry Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
* Homestead Valve Mfg. Co.
Hooven, Owens, Rentschler Co.
* Lidgerwood Mfg. Co.
* Link-Belt Co.
Lunkenheimer Co.
Mesta Machine Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Royersford Fdry. & Mch. Co.
Weimer Machine Works Co.
* Wood & Co., R. D.

Castings, Semi-Steel
Buffalo Fdry. & Mch. Co.
Builders Iron Foundry
* Caldwell & Son Co., H. W.
* Hill Clutch Co.
Hooven, Owens, Rentschler Co.
* Link-Belt Co.
Lunkenheimer Co.
Mesta Machine Co.
* Wood & Co., R. D.

Castings, Steel
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Cement, Belt
* Schieren Co., Chas. A.

Cement, High Temperature
* Johns-Manville Co., H. W.

Cement Machinery
* Caldwell & Son Co., H. W.
* Hill Clutch Co.
* Link-Belt Co.

Centrifugal Pumps
(See Pumps, Centrifugal)

Chain Belts and Links
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Jeffrey Mfg. Co.
* Link-Belt Co.

Chain Drives
* Caldwell & Son Co., H. W.
* Link-Belt Co.

Chain Grate Stokers
(See Stokers, Chain Grate)

Channeling Machines, Mine and Quarry
* Ingersoll-Rand Co.

Charging Machines, Furnace
* Alliance Machine Co.
Morgan Engineering Co.

Chemicals
Scientific Materials Co.

Chimneys, Steel
(See Stacks, Steel)

Chucking Machines
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co.
* Warner & Swasey Co.

Chutes
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Circulators, Feed Water
Schutte & Koerting Co.

Circulators, Steam Heating
Schutte & Koerting Co.

Clamps, Pipe-Joint
Yarnall-Waring Co.

Clamps, Wire Rope
(See Wire Rope Fastenings)

Clutch Leathers
(See Leathers, Automobile)

Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1916 Volume

"Everything For Lubrication But The Lubricants"

They Filter Over Half a Million Gallons of Oil per Day

The Peterson Power Plant Oil Filters shown above were installed in a 120,000 k. w. Power Plant. They are constructed of heavy steel plate and each has a filtering capacity of 125 gallons of oil per minute, or a total of 540,000 gallons per day.

The Peterson Power Plant Oil Filter

has been adopted for nearly every large oiling and filtering system recently installed. Some of these systems are handling over a million gallons of oil per day. On the other hand, we build smaller filters having capacities as low as 20 gallons of oil per day.

The Peterson Oil Filter has been installed in recent important power plants because the best known scientific principles are incorporated in its design. The filtering material is so arranged that every square inch is equally effective, rendering the use of an excessive quantity unnecessary and the filtering units can be removed, cleaned and replaced in less than a minute.

The services of our Lubrication Engineering Department which designed these mammoth oiling systems are at your disposal even if you only require a small system. Why not avail yourself of this service which is so cheerfully given.

If you are not familiar with the Peterson Power Plant Oil Filter, ask for a copy of our bulletin O-10. It discusses the subject of oil purification and cites tests which prove that the Peterson Filter has an efficiency of practically 100%.

THE RICHARDSON-PHENIX CO.

LUBRICATION ENGINEERS AND MANUFACTURERS

WORKS: 129 RESERVOIR AVE. MILWAUKEE, WIS.

216

Clutches, Friction
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Eastern Machinery Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
* Moore & White Co.
* Wood's Sons Co., T. B.

Coal and Ash Handling Machinery
Brown Hoisting Machinery Co.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Green Engineering Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
* Shepard Electric Crane & Hoist Co.

Coal Bins
Brown Hoisting Machinery Co.
* Link-Belt Co.

Coal Crushers
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.

Coal Mine Equipments and Supplies
Jeffrey Mfg. Co.

Coal Mining Machinery
* Ingersoll-Rand Co.
Jeffrey Mfg. Co.

Coaling Stations, Locomotive
* Hunt Co., Inc., C. W.
* Link-Belt Co.

Cocks, Air and Gage
* Ashton Valve Co.
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
Walworth Mfg. Co.

Cocks, Blowoff
* Crane Co.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Cocks, Three-way and Four-Way
* Crane Co.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Coils, Pipe
* National Pipe Bending Co.
* Vilter Mfg. Co.

Coke Oven Machinery
* Alliance Machine Co.

Cold Storage Plants
* De La Vergne Machine Co.

Collars, Shafting
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hill Clutch Co.
* Royersford Fdry. & Mch. Co.
* Wood's Sons Co., T. B.

Combustion Recorders
* Defender Automatic Regulator Co.
Foxboro Co.
* Precision Instrument Co.
* Sarco Co., Inc.

Compressors, Air
Buffalo Fdry. & Mch. Co.
* General Electric Co.
Goulds Manufacturing Co.
Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Otto Gas Engine Works
* Roots Co., P. H. & F. M.
Wickes Bros.

Compressors, Air, Compound
* Ingersoll-Rand Co.
Mesta Machine Co.

Compressors, Ammonia
* Vilter Mfg. Co.

Compressors, Gas
Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
Mesta Machine Co.
* Roots Co., P. H. & F. M.

Concrete Hardener
Sonneborn Sons, Inc., L.

Concrete Machinery
* Chain Belt Co.

Condensers
Buffalo Fdry. & Mch. Co.
Davidson Co., M. T.
Westinghouse Elec. & Mfg. Co.

Condensers, Ammonia
* De Le Vergne Machine Co.
* Vilter Mfg. Co.

Condensers, Barometric
Buffalo Fdry. & Mch. Co.
* Ingersoll-Rand Co.
Mesta Machine Co.

Condensers, Jet
Davidson Co., M. T.
General Condenser Co.
Schutte & Koerting Co.

Condensers, Surface
Buffalo Fdry. & Mch. Co.
Davidson Co., M. T.
General Condenser Co.
Westinghouse Elec. & Mfg. Co.

Conduit
* American Vulcanized Fibre Co.
* Johns-Manville Co., H. W.
Sprague Electric Works

Controllers, Automatic, for Temperature or for Pressure
(See Regulators)

Controllers, Electric
* General Electric Co.
Morgan Engineering Co.
Sprague Electric Works
Westinghouse Elec. & Mfg. Co.

Converters, Steel
Whiting Foundry Equip. Co.

Converters, Synchronous
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Conveying Machinery
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Conveyors, Belt
* Caldwell & Son Co., H. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Conveyors, Bucket, Pan or Apron
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Conveyors, Screw
* Caldwell & Sons Co., H. W.
* Chain Belt Co.
Jeffrey Mfg. Co.
* Link-Belt Co.

Cooling Ponds, Spray
Schutte & Koerting Co.
* Spray Engineering Co.

Cooling Towers
* Spray Engineering Co.

Copper, Drawn
* Roebling's Sons Co., John A.

Copper, Wire and Cables
(See Wires and Cables, Electrical)

Copper Converting Machinery
* Alliance Machine Co.

Core Ovens
Whiting Foundry Equip. Co.

Corliss Engines
(See Engines, Corliss)

Counters, Revolution
* Ashton Valve Co.
Foxboro Co.
* Veeder Mfg. Co.

Countershafts
Builders Iron Foundry
* Hill Clutch Co.
* Wood's Sons Co., T. B.

Counting Machines, Automatic
* Veeder Mfg. Co.

Couplings, Flexible
* Falls Clutch & Machinery Co.
Hooven, Owens, Rentschler Co.
* Roots Co., P. H. & F. M.

Couplings, Pipe
* Central Foundry Co.
* Crane Co.
Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Couplings, Shaft
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Cumberland Steel Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
* Link-Belt Co.
* Moore & White Co.
* Royersford Fdry. & Mch. Co.
* Wood's Sons Co., T. B.

Couplings, Union
(See Unions)

Couplings, Universal Joint
* Wood's Sons Co., T. B.

Coverings, Steam Pipe
* Johns-Manville Co., H. W.

Cranes, Electric Traveling
* Alliance Machine Co.
Box & Co., Alfred
Morgan Engineering Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.
Toledo Bridge & Crane Co.
Whiting Foundry Equip. Co.

Cranes, Gantry
* Alliance Machine Co.
Brown Hoisting Machinery Co.
* Link-Belt Co.
Morgan Engineering Co.
Northern Engineering Works
Orton & Steinbrenner Co.
Toledo Bridge & Crane Co.
Whiting Foundry Equip. Co.

Cranes, Hand Power
Box & Co., Alfred
Brown Hoisting Machinery Co.
* Clyde Iron Works
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.
Toledo Bridge & Crane Co.
Whiting Foundry Equip. Co.

Cranes, Hydraulic
* Alliance Machine Co.
Whiting Foundry Equip. Co.
Wood & Co., R. D.

Cranes, Jib
* Alliance Machine Co.
Box & Co., Alfred
Brown Hoisting Machinery Co.
Morgan Engineering Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.
Toledo Bridge & Crane Co.
Whiting Foundry Equip. Co.
* Wood & Co., R. D.

Cranes, Locomotive
Brown Hoisting Machinery Co.
* Link-Belt Co.
Morgan Engineering Co.
Orton & Steinbrenner Co.

Cranes, Pillar
Brown Hoisting Machinery Co.
Northern Engineering Works
Orton & Steinbrenner Co.
Toledo Bridge & Crane Co.
Whiting Foundry Equip. Co.

Cranes, Portable
Brown Hoisting Machinery Co.
* Clyde Iron Works
* Lidgerwood Mfg. Co.
* Link-Belt Co.

Crushers, Roll
Eastern Machinery Co.
Jeffrey Mfg. Co.
Orton & Steinbrenner Co.
* Link-Belt Co.

Crushing and Grinding Machinery
* Fulton Iron Works
Jeffrey Mfg. Co.

Cupolas
* Bigelow Co.
Connelly Boiler Co., D
Northern Engineering Works
Whiting Foundry Equip. Co.

Cutters, Bolt
Greenfield Tap & Die Corp.

Damper Regulators
(See Regulators, Damper)

Derricks and Derrick Fittings
* Clyde Iron Works
* Lidgerwood Mfg. Co.

Destructors, Refuse
Power Specialty Co.

Die Castings
(See Castings, Die)

Dies, Screw and Thread Cutting
Greenfield Tap & Die Corp.
* Jones & Lamson Machine Co.

Dies, Self-opening
Greenfield Tap & Die Corp.
* Jones & Lamson Machine Co.

Digesters
* Bigelow Co.

Digesters, Pulp
Hooven, Owens, Rentschler Co.

Discs, Valve
(See Valve Discs)

Distillers
Davidson Co., M. T.

Distilling Apparatus
Scientific Materials Co.

Drainage Systems
Morehead Mfg. Co.

Dredges, Hydraulic
* Morris Machine Works

Dredges, Land
Wickes Bros.

Drilling Machines, Pneumatic
* Ingersoll-Rand Co.

Drilling Machines, Rock
* Ingersoll-Rand Co.
Wickes Bros.

Drills, Coal and Slate
Jeffrey Mfg. Co.

Drinking-Fountains, Sanitary
* Johns-Manville Co., H. W.
Manufacturing Equipment & Engrg. Co.

Drop Forgings, Hammers, Presses, etc.
(See Forgings, Hammers, Presses, etc., Drop)

Dryers, Drum
Buffalo Fdry. & Mch. Co.

Dryers, Rotary
* Bigelow Co.
Buffalo Fdry. & Mch. Co.
Whiting Foundry Equip. Co.

Dryers, Vacuum
Buffalo Fdry. & Mch. Co.

Drying Apparatus
Buffalo Fdry. & Mch. Co.

Dust Arresters (for Tumbling Mills)
Whiting Foundry Equip. Co.

Dustproofing Materials
Sonneborn Sons, Inc., L.

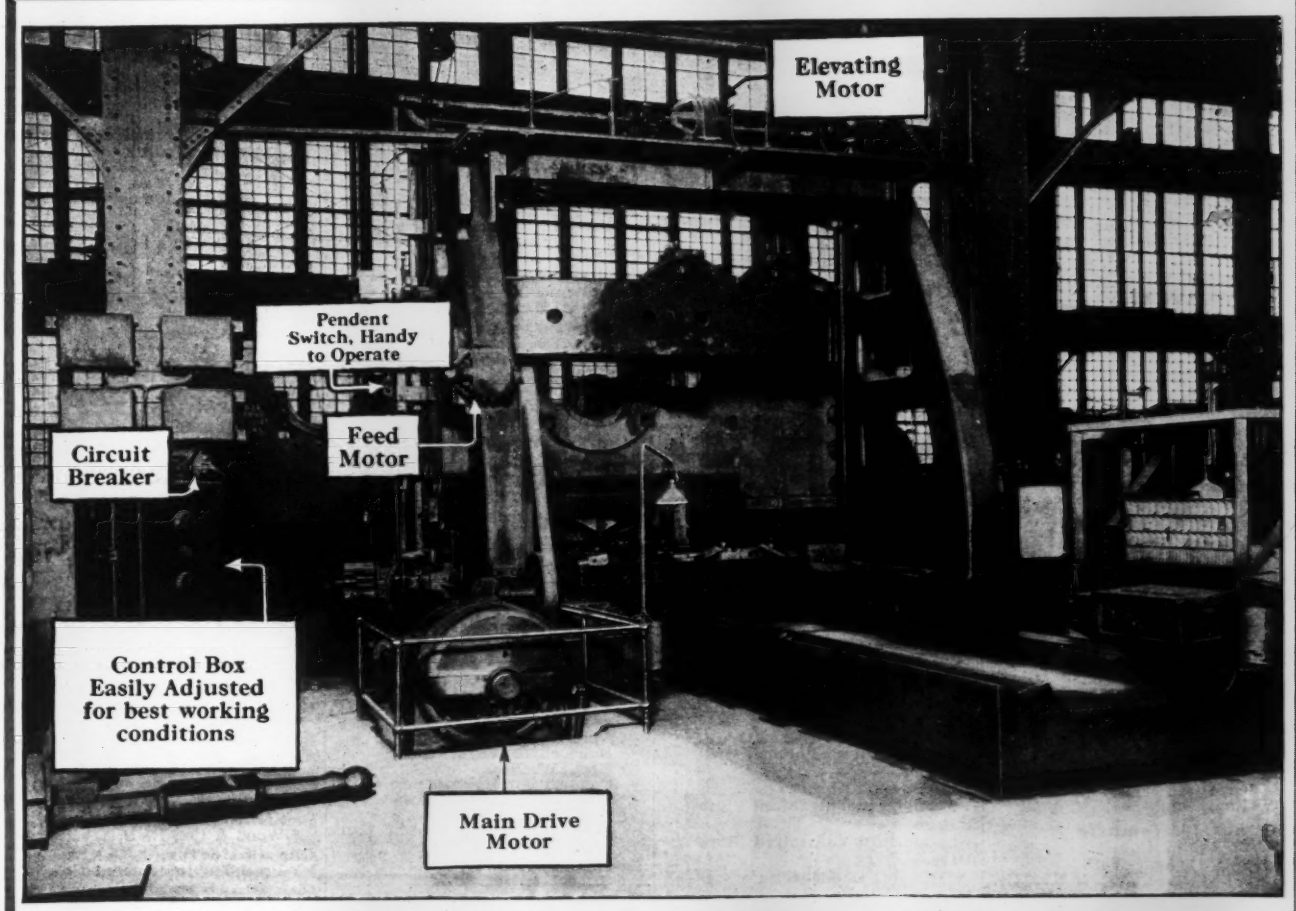
Dynamometers, Electric
Sprague Electric Works

Ejectors
Lunkenheimer Co.
Schutte & Koerting Co.

Ejectors, Ash, Hydraulic
Davidson Co., M. T.

Ejectors, Ash, Pneumatic
* Green Engineering Co.

Electric Generators, Hoists, Trucks, Welding, etc.
(See Generators, Hoists, Trucks, Welding, etc., Electric)



Hundreds of G-E Planer Drives are in Successful Operation

The first G-E Planer Drive, built five years ago, and hundreds built since then are in use throughout this country. Repeat orders constantly testify to their splendid operating records.

Carefully consider the following advantages of this equipment:

Vastly more economical in operation and upkeep than any other existing drive.

Maximum cutting speed always sustained, giving greatly increased production.

Reverses remarkably close to a line.

Standard motor speeds 250-1,000 r.p.m.

Many speed combinations, allowing slowest cutting and highest return speed to be combined.

Freedom from shocks, giving quickest reversals possible without jar.

Unexpected return of current to wires always finds motor and control apparatus ready to receive it.

Quiet operation.

Sparkless commutation.

Trouble proof control in easy reach of operator.

This equipment is conservatively rated and has ample power. Investigate the power rating of the motor you buy.

General Electric Company

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
Dayton, Ohio
Denver, Colo.
Des Moines, Iowa
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
Fort Wayne, Ind.
Hartford, Conn.
Indianapolis, Ind.

General Offices: Schenectady, N. Y.

ADDRESS NEAREST OFFICE

Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Youngstown, Ohio

For MICHIGAN BUSINESS refer to General Electric Company of Michigan, Detroit. For TEXAS, OKLAHOMA and ARIZONA BUSINESS refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City.
For CANADIAN BUSINESS refer to Canadian General Electric Company, Ltd., Toronto, Ont. GENERAL FOREIGN SALES OFFICES, Schenectady, N. Y.; 30 Church St., New York City; 83 Cannon St., London, E. C., England. 6545

Electrical Machinery
* Crocker-Wheeler Co.
Electro Dynamic Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Electrical Measuring Instruments
(See Instruments, Electrical Measuring)

Electrical Supplies
* General Electric Co.
* Johns-Manville Co., H. W.

Electrical Testing
Electrical Testing Laboratories, Inc.

Elevating and Conveying Machinery
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hill Clutch Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Elevators, Electric
Eastern Machinery Co.
Northern Engineering Works
Whiting Foundry Equip. Co.

Elevators, Inclined
(See Carriers and Elevators Freight, Continuous)

Elevators, Passenger and Freight
Eastern Machinery Co.
Northern Engineering Works
Whiting Foundry Equip. Co.

Elevators, Pneumatic
Whiting Foundry Equip. Co.

Emery Wheel Dressers
Builders Iron Foundry

Engine Stops
Golden-Anderson Valve Specialty Co.
Schutte & Koerting Co.

Engineers, Consulting
(See Directory of Consulting Engineers)

Engines, Automatic
* Ball Engine Co.
* Erie City Iron Works
Westinghouse Elec. & Mfg. Co.

Engines, Blowing
Hooven, Owens, Rentschler Co.
Mesta Machine Co.
Mackintosh, Hemphill & Co.
Weimer Machine Works Co.

Engines, Corliss
* Ball Engine Co.
* Fulton Iron Works
* Harris-Corliss Engine & Machine Co.
Hooven, Owens, Rentschler Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
* Vilter Mfg. Co.

Engines, Gas and Gasoline
* De La Vergne Machine Co.
Hooven, Owens, Rentschler Co.
Mesta Machine Co.
* National Meter Co.
Otto Gas Engine Works
Westinghouse Elec. & Mfg. Co.

Engines, High Speed
* Ball Engine Co.
* Erie City Iron Works
* Fulton Iron Works

Engines, Hoisting
(See Hoists, Steam)

Engines, Oil
* De La Vergne Machine Co.
* Fulton Iron Works
Otto Gas Engine Works

Engines, Joppet Valve, for Superheated Steam
* Erie City Iron Works
Mesta Machine Co.

Engines, Pumping
Davidson Co., M. T.
Hooven, Owens, Rentschler Co.
* Morris Machine Works
Otto Gas Engine Works
* Wood & Co., R. D.

Engines, Steam
* Ball Engine Co.
* Clyde Iron Works
* Erie City Iron Works
* Fulton Iron Works
* Harris-Corliss Engine & Machine Co.
Hooven, Owens, Rentschler Co.
* Lidgerwood Mfg. Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
* Morris Machine Works
* Vilter Mfg. Co.
Weimer Machine Works Co.
Westinghouse Elec. & Mfg. Co.

Engines, Steering
* Lidgerwood Mfg. Co.

Engines, Uniflow
Mesta Machine Co.

Evaporators
Buffalo Fdry. & Mch. Co.
Davidson Co., M. T.

Excavating Machinery
* Clyde Iron Works
* Lidgerwood Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.

Exhausters, Gas
* Roots Co., P. H. & F. M.
Schutte & Kotering Co.

Expansion Joints
(See Joints, Expansion)

Extractors, Tar
Smith Gas Engineering Co.

Factory Equipment, Metal
Manufacturing Equipment & Engrg. Co.

Fans, Electric
* General Electric Co.
Sprague Electric Works

Fans, Exhaust and Ventilating
Jeffrey Mfg. Co.
Sprague Electric Works

Feed Water Circulators, Heaters, Heaters and Purifiers, Regulators, etc.
(See Circulators, Heaters, Heaters and Purifiers, Regulators, etc., Feed Water)

Feeders, Pulverized Fuel
Locomotive Pulverized Fuel Co.

Ferrules
* American Vulcanized Fibre Co.

Fibre
* American Vulcanized Fibre Co.

Filters, Air
General Condenser Co.

Filters, Oil
* Richardson-Phenix Co.

Filters, Water
* Scaife & Sons Co., Wm. B.

Fire Tube Boilers
(See Boilers, Tubular)

Fire Brick, Hydrants, etc.
(See Brick, Hydrants, etc.)

Fittings, Ammonia.
* Crane Co.
* De La Vergne Machine Co.
* Vilter Mfg. Co.
Walworth Mfg. Co.

Fittings, Flanged.
Builders Iron Foundry
* Central Foundry Co.
* Crane Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Fittings, Hydraulic
* Crane Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Fittings, Pipe
* Central Foundry Co.
* Crane Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Walworth Mfg. Co.

Fittings, Steel
* Crane Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Flanges
* Crane Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Flanging Machines
Morgan Engineering Co.

Floor Stands
* Crane Co.
Davis Regulator Co., G. M.
Lunkenheimer Co.
Ludlow Valve Mfg. Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walworth Mfg. Co.

Forges
* Best, W. N.
* Gilbert & Barker Mfg. Co.
* Ingersoll-Rand Co.
* Roots Co., P. H. & F. M.

Forging Presses
(See Presses, Forging)

Forgings, Steel
Mesta Machine Co.

Foundry Equipment
Northern Engineering Works
Whiting Foundry Equip. Co.

Friction Clutches, Hoists, etc.
(See Clutches, Hoists, etc., Friction)

Friction Drives
Rockwood Mfg. Co.

Frictions, Fibre
* American Vulcanized Fibre Co.

Frictions, Paper and Iron
* Caldwell & Son Co., H. W.
Rockwood Mfg. Co.

Fuel Economizers
(See Economizers, Fuel)

Furnace Linings
(See Linings, Furnace)

Furnaces, Annealing and Tempering
* Best, W. N.
* Gilbert & Barker Mfg. Co.
Whiting Foundry Equip. Co.

Furnaces, Boiler
American Engineering Co.
* Babcock & Wilcox Co.
* Best, W. N.
Combustion Engineering Corp.
* Green Engineering Co.
* Murphy Iron Works
Riley Stoker Co., Ltd., Sanford

Furnaces, Gas
* Gilbert & Barker Mfg. Co.

Furnaces, Laboratory
Scientific Materials Co.

Furnaces, Melting
* Best, W. N.
* Gilbert & Barker Mfg. Co.
Whiting Foundry Equip. Co.

Furnaces, Oil
* Best, W. N.
* Gilbert & Barker Mfg. Co.
* Ingersoll-Rand Co.
Whiting Foundry Equip. Co.

Furnaces, Smokeless
American Engineering Co.
* Babcock & Wilcox Co.
Combustion Engineering Corp.
* Green Engineering Co.
* Murphy Iron Works
Riley Stoker Co., Ltd., Sanford

Fuses
* Johns-Manville Co., H. W.

Gage Boards
* Ashton Valve Co.
Foxboro Co.

Gage Testers
* Ashton Valve Co.

Gages, Ammonia
* Ashton Valve Co.
Foxboro Co.

Gages, Ball
* Atlas Ball Co.

Gages, Differential Pressure
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Defender Automatic Regulator Co.
Foxboro Co.
* Precision Instrument Co.

Gages, Draft
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Defender Automatic Regulator Co.
Foxboro Co.
* Precision Instrument Co.
* Taylor Instrument Cos.

Gages, Hydraulic
* Ashton Valve Co.
Foxboro Co.

Gages, Oil Level
* Richardson-Phenix Co.

Gages, Pressure
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Defender Automatic Regulator Co.
Foxboro Co.

Gages, Surface, Depth, Dial, etc.
* Atlas Ball Co.

Gages, Thread
Greenfield Tap & Die Corp.

Gages, Vacuum
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bristol Co.
Foxboro Co.
* Precision Instrument Co.
* Taylor Instrument Cos.

Gages, Water
* Ashton Valve Co.
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
Walworth Mfg. Co.

Gages, Water Level
* Bristol Co.
Foxboro Co.

Gas Analysis Apparatus
* Defender Automatic Regulator Co.
Foxboro Co.
* Precision Instrument Co.
Scientific Materials Co.

Gas Burners, Compressors, Engines, Exhausters, Holders, Producers, etc.
(See Burners, Compressors, Engines, Exhausters, Holders, Producers, etc., Gas)

Gas Cleaning Plants
Smith Gas Engineering Co.
* Wood & Co., R. D.

Gas Collectors
* Precision Instrument Co.

Gas Plant Machinery
* Wood & Co., R. D.

Gas Plants, Fuel
* Gilbert & Barker Mfg. Co.

Gas Valves
Smith Gas Engineering Co.

Gaskets
* American Vulcanized Fibre Co.
* Goodrich Co., B. F.
Greene, Tweed & Co.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Powers Specialty Co.
Quaker City Rubber Co.

Gasoline
* Texas Co.

Gates, Blast
* Roots Co., P. H. & F. M.

Gates, Cut-off
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hunt Co., Inc., C. W.
* Link-Belt Co.

Gates, Sluice
Ludlow Valve Mfg. Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Wood & Co., R. D.

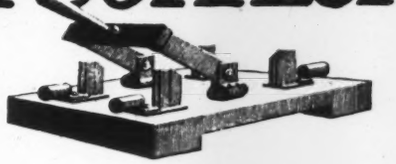
Gear Shapers
* Fellows Gear Shaper Co.

Gears, Cut
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
James Mfg. Co., D. O.
Jeffrey Mfg. Co.
* Link-Belt Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
New Process Gear Corp.
* Hill Clutch Co.
Holyoke Machine Co.
Northern Engineering Works

Gears, Fibre
* American Vulcanized Fibre Co.
* General Electric Co.
James Mfg. Co., D. O.
New Process Gear Corp.

Gears, Machine Molded
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Hill Clutch Co.
Mesta Machine Co.

Vul-Cot Fibre



IN this knife switch the cross piece and the handle are Vul-Cot Fibre—completely machined at our Wilmington shops.

There are thousands of other electrical and mechanical fibre parts, some of which we make year after year by the million—noiseless fibre gears and pinions, friction discs and washers for friction drives, etc.

Vul-Cot Fibre is furnished in sheets, rods, bars, tubes or ready-machined to your specifications. We will gladly extend every engineering assistance, and send prices and full particulars upon request.

American Vulcanized Fibre Co.
565-575 Equitable Building, Wilmington, Delaware

Branches:
St. Louis Boston New York Philadelphia
Pittsburgh Cleveland Detroit
Complete stock for immediate shipment at Chicago
Canadian Agents:
Northern Electric Co., Ltd., Montreal Halifax Winnipeg
Regina Ottawa Toronto Calgary Vancouver

"BUFLOKAST" Chemical Plants

Chemical Equipment and Complete Plants for producing heavy chemicals, acids, caustic alkalies and organic chemicals, including Aniline, Phenol, Picric Acid, Paranitraniline, Beta Naphthol and other intermediate products for Coal-Tar Colors.

Special apparatus for all operations of the organic chemical industry such as nitration, sulfonation, reduction, chlorination, caustic fusion, etc.

"BUFLOVAK" Vacuum Apparatus

"The Highest Attainment in Vacuum Dryer Construction"
DRYERS FOR ALL MATERIALS

VACUUM SHELF DRYERS, for drying materials that can be handled in pans or trays.
VACUUM ROTARY DRYERS, for any material that permits being tumbled while drying.
VACUUM DRUM DRYERS, for drying any liquids containing solids.

Evaporators, Condensers, Dry Vacuum Pumps, Solvent Reclaiming Apparatus, Impregnating Apparatus, Etc.
Catalog Mailed on Request.

Buffalo Foundry & Machine Co.
37 Winchester Ave. Buffalo, N.Y.
New York Office 17 Battery Place

For Concrete Floors

LAPIDOLITH
TRADE MARK

YOUR concrete floors are dusting—wearing away.

Lapidolith will harden the concrete and thereby prevent the concrete dust so injurious to your machinery and merchandise.

Lapidolith is a liquid chemical hardener—easily applied—positive in its action. It is universally used.

Let us show you concrete floors in your city made dustproof, wearproof and waterproof by Lapidolith.

Write for book of testimonial letters, sample flask and Lapidolized block—Dept. 19.

L. Sonneborn Sons, Inc.
264 Pearl Street New York

(Also Manufacturers of Cemcoat, the Washable Wall Coating)

Gears, Rawhide
James Mfg. Co. D. O.
New Process Gear Corp.

Gears, Speed Reduction
James Mfg. Co., D. O.
Westinghouse Elec. Mfg. Co.

Gears, Worm
* Caldwell & Son Co., H. W.
* Chain Belt Co.
James Mfg. Co., D. O.
* Link-Belt Co.

Generating Sets
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Generators, Electric
* Crocker-Wheeler Co.
* General Electric Co.
Sprague Electric Works
Westinghouse Elec. & Mfg. Co.

Glass Blowing
Scientific Materials Co.

Glass Machinery, Plate
Hooven, Owens, Rentschler Co.

Governors, Gas Engine
* Pickering Governor Co.

Governors, Pump
Davis Regulator Co., G. M.
* Richardson-Phenix Co.

Governors, Steam Engine
* Pickering Governor Co.

Governors, Steam Turbine
* Pickering Governor Co.

Governors, Water Wheel
Holyoke Machine Co.

Grates and Grate Bars
Combustion Engineering Corp.

Grates, Dumping
Combustion Engineering Corp.

Grates, Shaking
Combustion Engineering Corp.
* Erie City Iron Works
* Springfield Boiler & Mfg. Co.

Greases
* Royersford Fdry. & Mch. Co.
* Texas Co.

Grease Cups
(See Oil and Grease Cups)

Grease Extractors
(See Separators, Oil)

Grinders
* Brown Co., A. & F.

Grinding or Polishing Machines
Builders Iron Foundry
Defiance Machine Works
Heald Machine Co.
* Royersford Fdry. & Mch. Co.

Grinding Machines, Cutter
Heald Machine Co.
Le Blond Machine Tool Co.

Grinding Machines, Cylindrical
Heald Machine Co.

Grinding Machines, Drill
Heald Machine Co.

Grinding Machines, Internal
Heald Machine Co.

Grinding Machines, Portable, Pneumatic
* Ingersoll-Rand Co.

Grinding Machines, Surface
Heald Machine Co.

Grinding Machines, Tool
Heald Machine Co.
Le Blond Machine Tool Co.

Gun and Motor Carriages
Morgan Engineering Co.

Hammers, Drop
* Alliance Machine Co.

Hammers, Pneumatic
* Ingersoll-Rand Co.

Hammers, Steam
* Alliance Machine Co.
Buffalo Fdry. & Mach. Co.
Morgan Engineering Co.

Hangers, Shaft
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
* Royersford Fdry. & Mch. Co.
* Woods Sons Co., T. B.

Head Gates
Holyoke Machine Co.

Heaters, Feed Water (Closed)
* Erie City Iron Works
* National Pipe Bending Co.
Schutte & Koerting Co.

Heaters and Mixers, Water, Instantaneous
Manufacturing Equipment & Engrg. Co.

Heaters and Purifiers, Feed Water (Open)
* Erie City Iron Works
* National Pipe Bending Co.
* Springfield Boiler & Mfg. Co.
* Wickes Boiler Co.

Heating Boilers
(See Boilers, Heating)

Heating and Ventilating Apparatus
* Smith Co., H. B.

Hoisting and Conveying Machinery
* Box & Co., Alfred
Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Lidgerwood Mfg. Co.
* Link-Belt Co.
Northern Engineering Works
Orton & Steinbrenner Co.
* Shepard Electric Crane & Hoist Co.
Whiting Foundry Equip. Co.

Hoists, Air
* Ingersoll-Rand Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.
Whiting Foundry Equip. Co.

Hoists, Belt
* Clyde Iron Works
* Lidgerwood Mfg. Co.

Hoists, Chain
Box & Co., Alfred
* Ford Chain Block & Mfg. Co.
Northern Engineering Works
Whiting Foundry Equip. Co.
Yale & Towne Mfg. Co.

Hoists, Electric
* Alliance Machine Co.
Box & Co., Alfred
Brown Hoisting Machinery Co.
* Clyde Iron Works
* General Electric Co.
* Hunt Co., Inc., C. W.
* Lidgerwood Mfg. Co.
* Link-Belt Co.
Northern Engineering Works
Orton & Steinbrenner Co.
* Shepard Electric Crane & Hoist Co.
Sprague Electric Works
Whiting Foundry Equip. Co.

Hoists, Friction
Eastern Machinery Co.
Whiting Foundry Equip. Co.

Hoists, Gas and Gasoline
* Lidgerwood Mfg. Co.
Otto Gas Engine Works

Hoists, Mine
* Lidgerwood Mfg. Co.

Hoists, Skip
Brown Hoisting Machinery Co.
* Hunt Co., Inc., C. W.
* Lidgerwood Mfg. Co.
* Link-Belt Co.

Hoists, Steam
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Lidgerwood Mfg. Co.
* Morris Machine Works
Orton & Steinbrenner Co.

Holders, Gas
* Wood & Co., R. D.

Hose, Air
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Quaker City Rubber Co.
Sprague Electric Works

Hose, Linen
* Goodrich Co., B. F.

Hose, Metallic
* Johns-Manville Co., H. W.
Sprague Electric Works

Hose, Oil
* Goodrich Co., B. F.
Quaker City Rubber Co.

Hose, Rubber
* Goodrich Co., B. F.
Quaker City Rubber Co.

Hose, Steam
* Goodrich Co., B. F.
Quaker City Rubber Co.
Sprague Electric Works

Hose, Suction
* Goodrich Co., B. F.
Quaker City Rubber Co.

Hose Attachments (Couplings, Bands, Holders, Clamps, etc.)
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Quaker City Rubber Co.

Hydrants, Fire
Ludlow Valve Mfg. Co.
* Wood & Co., R. D.

Hydraulic Jacks, Rams, Presses, Turbines, etc.
(See Jacks, Rams, Presses, Turbines, etc., Hydraulic)

Hydraulic Machinery
* Alliance Machine Co.
Holyoke Machine Co.
Mackintosh, Hemphill & Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Hydrokineters
Schutte & Koerting Co.

Hydrometers
Scientific Materials Co

Hygrometers
* Bristol Co.
Foxboro Co.
Scientific Materials Co.
* Taylor Instrument Co.

Ice and Refrigeration Machinery
* De La Vergne Machine Co.
* Johns-Manville Co., H. W.
* Vilter Mfg. Co.

Ice Tools
* Caldwell & Son Co., H. W.

Impregnating Apparatus
Buffalo Fdry. & Mch. Co.

Incandescent Lamps
(See Lamps, Incandescent)

Indicator Posts
* Crane Co.
Ludlow Valve Mfg. Co.
* Pratt & Cady Co., Inc.
* Wood & Co., R. D.

Indicators, CO_2
Bacharach Industrial Instrument Co.
Foxboro Co.

Indicators, Engine
Bacharach Industrial Instrument Co.

Indicators, Sight Flow
* Richardson-Phenix Co.

Indicators, Speed
Foxboro Co.
* Veeder Manufacturing Co.
* Weston Electrical Instrument Co.

Industrial Railways
(See Railways, Industrial)

Ingot Strippers
* Alliance Machine Co
Morgan Engineering Co.

Injectors
Lunkenheimer Co.
Schutte & Koerting Co.

Instruments, Electrical Measuring
* Bristol Co.
* General Electric Co.
* Taylor Instrument Co.
Westinghouse Elec. & Mfg. Co.
* Weston Electrical Instrument Co.

Instruments, Physical
* Taylor Instrument Co.

Instruments, Recording
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
Builders Iron Foundry
Foxboro Co.
* General Electric Co.
* Precision Instrument Co.
Scientific Materials Co.
* Taylor Instrument Co.
Westinghouse Elec. & Mfg. Co
Yarnall-Waring Co.

Instruments, Testing
* Norma Co. of America

Insulating Materials (Elec.)
* American Vulcanized Fibre Co.
* Johns-Manville Co., H. W.

Insulating Materials (Heat and Cold)
* Johns-Manville Co., H. W.

Irrigation Systems
* Spray Engineering Co.

Jigs and Fixtures
* Cowdrey Machine Works, C. H.

Joints, Expansions
* Crane Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Power Specialty Co.
Walworth Mfg. Co.

Joints, Flanged Pipe
* Crane Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Jolt Ramming Machines
(See Rammers, Foundry)

Kettles
Buffalo Fdry. & Mch. Co.

Kettles, Soda
Manufacturing Equipment & Engrg. Co.

Laboratory Apparatus
Scientific Materials Co.

Laboratory Ware
Scientific Materials Co.

Ladles
Connelly Boiler Co., D.
Northern Engineering Works
Whiting Foundry Equip. Co.

Lamp Guards (Electric)
* Flexible Steel Lacing Co.

Lamps, Incandescent
* General Electric Co.
* Johns-Manville Co., H. W.
Westinghouse Elec. & Mfg. Co.

Land-Clearing Machinery
* Clyde Iron Works

Lathe Attachments
Le Blond Machine Tool Co.

Lathes
Builders Iron Foundry
* Harris-Corliss Engine & Machine Co.
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co.
* Warner & Swasey Co.
Wickes Bros.

Lathes, Automatic
* Jones & Lamson Machine Co.

Lathes, Brass
* Warner & Swasey Co.

Lathes, Chucking
* Jones & Lamson Machine Co.

Lathes, Speed
Le Blond Machine Tool Co.

Lathes, Turret
* Jones & Lamson Machine Co.
* Warner & Swasey Co.

Lathes, Turret, Vertical
King Machine Tool Co.

Leather Belting, Packing etc.
(See Belting, Packing, etc., Leather)

Leathers, Automobile
* Schieren Co., Chas. A.

Leathers, Pump
* Schieren Co., Chas. A.

Lighting Arresters
* General Electric Co.

Lining, Brake
* Johns-Manville Co., H. W.

Lining, Furnace
* Best, W. N.
* Johns-Manville Co., H. W.

Lining, Stack
* Johns-Manville Co., H. W.

Liquid Fuel Equipment
* Best, W. N.

Loaders, Wagon
* Chain Belt Co.
Jeffrey Mfg. Co.
* Link-Belt Co.

Lockers, Metal
Manufacturing Equipment & Engrg. Co.

Blueprints

The Wickes

Continuous Electric. Sells at **half** the **price.** Uses **half** the **current** of others. Perfect prints up to 48″ in width and of unlimited length.

Wickes Bros.

Department B

Saginaw - Mich.

FLEXCO-LOK Lamp Guards

Prevent Breakage and Loss of Time

Use ALLIGATOR Steel Belt Lacing

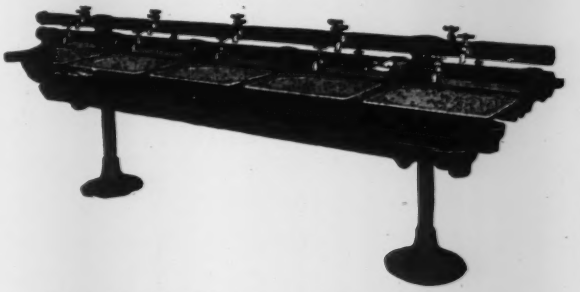
Never Lets Go

Flexible Steel Lacing Co.

522 So. Clinton Street

Chicago, Ill.

Your Men Will Appreciate a Clean Place to Wash



M. E. & E. Co. Washbowls

Every time each man uses M. E. & E. Co. Washbowls he is absolutely sure of a clean wash free from contamination.

M. E. & E. Co. Individual Washbowls are made in single and double batteries of any number. Any mechanic can make the simple pipe connections required.

Send for Our Complete Catalog

showing our line of Wash Bowls, Metal Lockers, All Steel Stools and Chairs with Inset Wood Seats, Stock and Storage Racks, Metal Shelving, Metal Vault Fixtures, Improved Soda Kettles, 40 and 60 gallons, Water Heaters and Instantaneous Mixers, Bubbling Drinking Fountains, Work Benches and Bench Legs, Drawing Stands, etc.

Manufacturing Equipment and Engineering Co.

Office and Showrooms—Boston, Mass., U. S. A.
Works—Framingham, Mass.
MAIL ADDRESS—Framingham, Mass., U. S. A.

THE FIRST BIG SPECIAL ISSUE

FOR the first time in the history of the Society, the Annual Meeting of this year will be reported in full in a single issue of the Journal. The Meeting will take place in New York, December 5 to 8, and the *complete* reports will appear in the January number.

A program of the broadest technical and general interest has been arranged; and the account of the proceedings which is to appear in the January Journal will practically constitute an expert review of the mechanical engineering experience and progress of the year.

From the advertising standpoint, the plans for the Annual Meeting Number provide for an issue so large and so informative that our members and other readers will find it well worth preserving for months to come as a reference compilation of all that is best in mechanical equipment and supplies.

In addition to the large volume of advertising matter to be carried, the Classified Index of this issue will be greatly enlarged both in size and scope, and in itself will comprise a reference feature of much value. Adequate listings in this Index will be included with all orders for space, provided such orders are received sufficiently early to permit of the necessary rearrangements of the Index.

Manufacturers of machinery, apparatus and materials utilized in manufacturing and power plants are invited to take advantage of the exceptional publicity value of this January Annual Meeting Number by arranging for appropriate space.

Circulation for January 10,500 copies
Forms close Dec. 11th, 1916

Reservations for space should be sent at an early date to

The American Society of Mechanical Engineers
29 West Thirty-ninth Street, New York

Locomotives, Compressed Air
* Ingersoll-Rand Co.

Locomotives, Electric
* General Electric Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Logging Machinery
*Clyde Iron Works
* Lidgerwood Mfg. Co.

Lubricants
* Royersford Fndry. & Mch. Co.
* Texas Co.

Lubricators, Cylinder
Crescent Mfg. Co.
* Greene, Tweed & Co.
Lunkenheimer Co.
* Richardson-Ppenix Co.

Lubricators, Force-Feed
* Greene, Tweed & Co.
Lunkenheimer Co.
* Pickering Governor Co.
* Richardson-Phenix Co.

Lubricators, Hydrostatic
Crescent Mfg. Co.
Lunkenheimer Co.

Machinery
(Is classified under the headings descriptive of character thereof)

Machine Work
* Brown Co., A. & F.
Builders Iron Foundry
* Caldwell & Son Co., H. W.
* Cowdrey Machine Works, C. H.
Defiance Machine Works
* Hill Clutch Co.
* Lammert & Mann
* Link-Belt Co.
Mesta Machine Co.
Weimer Machine Works Co.
* Wood & Co., R. D.

Mechanical Stokers
(See Stokers)

Metal Equipment
Manufacturing Equipment & & Engine Co.

Metallographical Apparatus
Scientific Materials Co.

Meters, Air and Gas
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
Builders Iron Foundry
Foxboro Co.
* General Electric Co.

Meters, Electric
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Meters, Feed Water
* Bailey Meter Co.
Builders Iron Foundry
Foxboro Co.
Yarnall-Waring Co.

Meters, Steam
* Bailey Meter Co.
Builders Iron Foundry
Foxboro Co.
* General Electric Co.

Meters, V-Notch
* Bailey Meter Co.
Yarnall-Waring Co.

Meters, Venturi
Builders Iron Foundry
* National Meter Co.

Meters, Water
* National Meter Co.

Micrometers
Greenfield Tap & Die Corp.

Microscopes
Scientific Materials Co.

Milling Attachments
Le Blond Machine Tool Co.

Milling Machines, Plain
Le Blond Machine Tool Co.
* Warner & Swasey Co.

Milling Machines, Universal
Le Blond Machine Tool Co.

Mills, Blooming and Slabbing
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Cinder, Water
Whiting Foundry Equip. Co.

Mills, Sheet and Plate
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Structural, Rail and Bar
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Sugar Cane
* Fulton Iron Works
Mesta Machine Co.

Mixers, Concrete
* Chain Belt Co.

Monorail Systems
(See Tramrail Systems, Overhead)

Motion Recorders
* Bristol Co.
Foxboro Co.

Motor-Generators
* Crocker-Wheeler Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Motors, Compressed Air
* Ingersoll-Rand Co.

Motors, Electric
* Crocker-Wheeler Co.
Electric Dynamic Co.
* General Electric Co
* Shepard Electric Crane & Hoist Co.
Sprague Electric Works
Westinghouse Elec. & Mfg. Co.

Nozzles, Aerating
* Spray Engineering Co.

Nozzles, Blast
Schutte & Koerting Co.

Nozzles, Sand and Air
* Ingersoll-Rand Co.
Lunkenheimer Co.

Nozzles, Spray
Schutte & Koerting Co.
Spray Engineering Co.

Odometers
* Veeder Manufacturing Co.

Oil and Grease Cups
* Crane Co.
Crescent Mfg. Co.
Lunkenheimer Co.

Oil Burners, Engines, Filters, Pumps, Separators, etc.
(See Burners, Engines, Filters, Pumps, Separators, etc. Oil)

Oil Burning Systems
* Best, W. N.
* Gilbert & Barker Mfg. Co.
Schutte & Koerting Co.

Oil Filtering Systems
* Richardson-Phenix Co.

Oil Storage Systems
* Richardson-Phenix Co.

Oil Tanks
Graver Tank Works, Wm.
* Richardson-Phenix Co.

Oilers, Sight Feed
Lunkenheimer Co.
* Richardson-Phenix Co.

Oilers, Telescopic
* Richardson-Phenix Co.

Oiling Devices
Lunkenheimer Co.
* Richardson-Phenix Co.

Oiling Systems
Lunkenheimer Co.
* Richardson-Phenix Co.

Oils, Fuel
* Texas Co.

Oils, Lubricating
* Texas Co.

Ore Handling Machinery
Brown Hoisting Machinery Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Toledo Bridge & Crane Co.

Packing, Asbestos
* Johns-Manville Co., H. W.

Packing, Hydraulic
* Goodrich, B. F.
* Greene, Tweed & Co.
* Johns-Manville Co., H. W.
Power Specialty Co.
Quaker City Rubber Co.
* Schieren Co., Chas. A.

Packing, Leather
* Schieren Co., Chas. A.

Packing, Metallic
* Johns-Manville Co., H. W.
Power Specialty Co.

Packing, Rod (Piston and Valve)
* Goodrich, B. F.
* Greene, Tweed & Co.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Power Specialty Co.
Quaker City Rubber Co.

Packing, Rubber
* Goodrich, B. F.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Quaker City Rubber Co.

Packing, Sheet
* American Vulcanized Fibre Co.
* Goodrich, B. F.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Quaker City Rubber Co.

Paint, Metal
* Johns-Manville Co., H. W.

Pans, Vacuum
Buffalo Fdry. & Mch. Co.

Paper Machinery
Holyoke Machine Co.
* Moore & White Co.

Pasteurizers
* Vitter Mfg. Co.

Pencils
American Lead Pencil Co.

Petroleum Products
* Texas Co.

Pickling Machines
Mesta Machine Co.

Pile Drivers
* Clyde Iron Works
* Lidgerwood Mfg. Co.

Pile Drivers, Sheet
* Ingersoll-Rand Co.

Pinions, Rolling Mill
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Pinions, Rawhide
New Process Gear Corp.

Pipe, Cast Iron
American Cast Iron Pipe Co.
Builders Iron Foundry
* Central Foundry Co.
Clow & Sons, James B.
Donaldson Iron Co.
Glamorgan Pipe & Foundry Co.
Lynchburg Foundry Co.
Massillon Iron & Steel Co.
Standard Cast Iron Pipe & Foundry Co.
United States Cast Iron Pipe & Foundry Co.

Pipe, Riveted Steel
Connell Boiler Co., D.
Graver Tank Works, Wm.
* Keeler Co., E.
* Springfield Boiler & Mfg. Co.

Pipe, Soil
* Central Foundry Co.

Pipe, Steel
* Crane Co.
Walworth Mfg. Co.

Pipe, Welded
* Crane Co.
* Pittsburgh Valve Fdry. & Const. Co.

Pipe, Wrought Iron
* Crane Co.
Walworth Mfg. Co.

Pipe Bending and Bends
* Crane Co.
National Pipe Bending Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Pipe Coils, Covering, Cutters, Fittings, Joints, etc.
(See Coils, Covering, Cutters, Fittings, Joints, etc., Pipe)

Pipe Cutting and Threading Machines
* Crane Co.
Greenfield Tap & Die Corp'n.

Pipe Joint Clamps
(See Clamps, Pipe Joint)

Plate Metal Work
(See Steel Plate Construction)

Platinum Ware
Scientific Materials Co.

Pneumatic Pumping Systems
(See Air Lift Pumping Systems)

Pneumatic Tools
* Ingersoll-Rand Co.

Polishing Machinery
Builders Iron Foundry
* Royersford Fdry. & Mch. Co.

Poppet Valve Engines
(See Engines, Poppet Valve)

Pots, Caustic
Buffalo Fdry. & Mch. Co.

Powdered Coal Equipment (for Boiler and Metallurgical Furnaces)
Locomotive Pulverized Fuel Co.

Power Transmission Machinery
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Eastern Machinery Co.
* Falls Clutch & Machinery Co.
Hill Clutch Co.
Holyoke Machine Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
Mesta Machine Co.
* Moore & White Co.
* Royersford Fdry. & Mch. Co.
* Wood's Sons Co., T. B.

Presses, Foot
Royersford Fdry. & Mch. Co.

Presses, Forging (Steam-Hydraulic)
Mesta Machine Co.
* Wood & Co., R. D.

Presses, Hydraulic
* Alliance Machine Co.
* Falls Clutch & Machinery Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Presses, Punching and Trimming
* Royersford Fdry. & Mch. Co.

Pressure Gages, Regulators, etc.
(See Gages, Regulators, etc., Pressure)

Producers, Gas
* De Le Vergne Machine Co.
Otto Gas Engine Works
Smith Gas Engineering Co.
Westinghouse Elec. & Mfg. Co.
* Wood & Co., R. D.

Propellers
* Morris Machine Co.

Pulleys, Iron
* Brown Co., A. & F.
* Chain Belt Co.
* Caldwell & Son Co., H. W.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
Jeffrey Mfg. Co.
* Wood's Sons Co., T. B.

Pulleys, Paper
Rockwood Mfg. Co.

Pulleys, Steel
* Caldwell & Son Co., H. W.

Pulleys, Wood
* Caldwell & Son Co., H. W.

Pulverized Fuel Feeders
(See Feeders, Pulverized Fuel)

Pulverizers
* Brown Co., A. & F.
Jeffrey Mfg. Co.

Pump Governors, Valves, etc.
(See Governors, Valves, etc., Pumps)

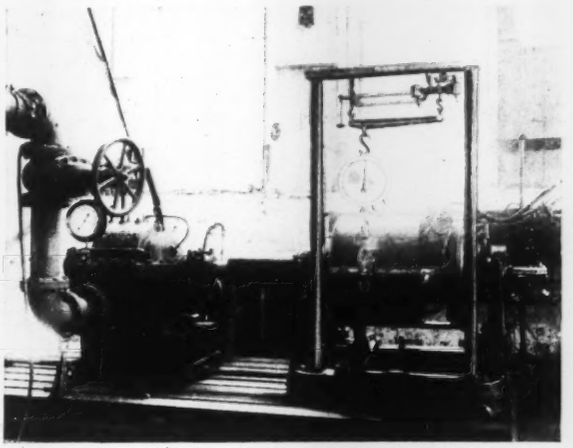
Pumping Engines
(See Engines, Pumping)

Pumping Machinery
Davidson Co., M. T.
Goulds Mfg. Co.
* Morris Co., I. P.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Air
Davidson Co., M. T.
General Condenser Co.
Goulds Mfg. Co.
Mesta Machine Co.
* Roots Co., P. H. & F. M.
Westinghouse Elec. & Mfg. Co.

Pumps, Ammonia
Davidson Co., M. T.

You Get Guaranteed Efficiency when you buy GOULDS CENTRIFUGAL PUMPS



One of the two Transmission Dynamometers used to prove Efficiencies of Goulds Centrifugal pumps before they are shipped.

This is due to the fact that we *know absolutely* and accurately what each pump will do under the conditions for which it is to be used and make our guarantee of efficiency on that basis.

Goulds Centrifugal Pumps are tested for power input by means of the only machine built for this purpose which gives accurate results—the transmission Dynamometer. Two of these Dynamometers are in use in our testing laboratory—one a 50 H. P. General Electric and the other a 150 H. P. Diehl Machine, the latter illustrated.

Goulds Centrifugals are tested for capacities by means of weir tanks and accurately calibrated nozzles. The most improved types of measuring instruments, gauges, mercury columns, tachometers, revolution counters, etc., are used.

Some of these pumps we test at the request of our customers; the others we test to prove to our own satisfaction before the pumps leave the factory, that they will do everything we claim for them. *This is one of the reasons why so many pump users rely on Goulds.*

THE GOULDS MANUFACTURING COMPANY
Main Office and Works - - Seneca Falls, N. Y.
BRANCH HOUSES: Boston, New York, Philadelphia, Chicago DISTRICT OFFICES: Pittsburgh, Atlanta, Baltimore, Houston

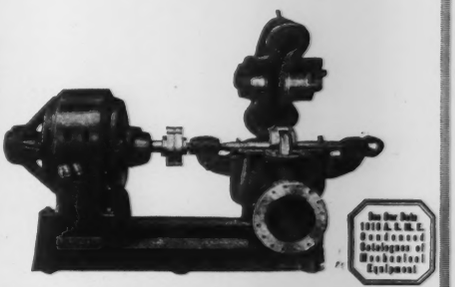
R. D. WOOD & CO.

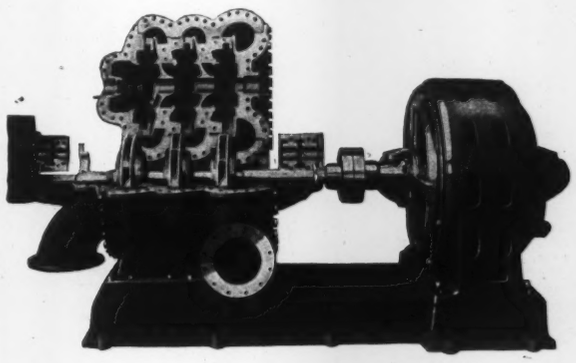
ENGINEERS
IRON FOUNDERS
MACHINISTS

PHILADELPHIA, PA.

BUILDERS OF Gas Holders, Single and Multiple Lift; Gas Plants; Gas Producer Power Plants; Hydraulic Presses and Heavy Hydraulic Machinery; Pumping Engines. Centrifugal Pumping Plants; Water Works Appliances; Steel Tanks; Sugar House Apparatus; Heavy Special Machinery; Theisen Washers.

MANUFACTURERS OF C. I. Pipe, Gas Works Apparatus, Centrifugal Pumps, Hydraulic Tools of all description, Hydrants and Valves, Gas Producers.





CENTRIFUGAL PUMPING MACHINERY

Morris Machine Works
Baldwinsville, N. Y.

HENION & HUBBELL, Agents
217-221 N. Jefferson St., Chicago, Ill.

HARRIS PUMP & SUPPLY CO., Agents
Pittsburgh, Pa.

H. A. PAINE, Agent
Houston, Texas

New York Office,
39-41 Cortlandt Street

CHARLOTTE, N. C.

Pumps, Boiler Feed
Davidson Co., M. T.
Goulds Mfg. Co.

Pumps, Centrifugal
Goulds Mfg. Co.
* Lammert & Mann
* Morris Co., I. P.
* Morris Machine Works
Westinghouse Elec. & Mfg. Co.
* Wood & Co., R. D.

Pumps, Condensation, with Automatic Receivers
Davidson Co., M. T.

Pumps, Deep Well
Davidson Co., M. T.
Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Morris Machine Works

Pumps, Dredging
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Dry Vacuum
(See Pumps, Vacuum)

Pumps, Electric
Goulds Mfg. Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Hand
Goulds Mfg. Co.

Pumps, Hydraulic Pressure
Davidson Co., M. T.
Goulds Mfg. Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Oil
Goulds Mfg. Co.
Lunkenheimer Co.
* Roots Co., P. H. & F. M.
* Richardson-Phenix Co.
* Wood & Co., R. D.

Pumps, Oil, Force-Feed
* Greene, Tweed & Co.
Lukenheimer Co
* Pickering Governor Co.
* Richardson-Phenix Co.

Pumps, Power
Davidson Co., M. T.
Goulds Mfg. Co.
Holyoke Machine Co.
* Wood & Co., R. D.

Pumps, Rotary
Goulds Mfg. Co.
Holyoke Machine Co.
* Lammert & Mann
* Roots Co., P. H. & F. M.

Pumps, Self-Measuring
* Richardson-Phenix Co.

Pumps, Steam
Davidson Co., M. T.

Pumps, Sump
Goulds Mfg. Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Tank
Davidson Co., M. T.
* Goulds Mfg. Co.
* Wood & Co., R. D.

Pumps, Turbine
* General Electric Co.
* Morris Machine Works
Westinghouse Elec. & Mfg. Co.
* Wood & Co., R. D.

Pumps, Vacuum
Buffalo Fdry. & Mch. Co.
Davidson Co., M. T.
General Condenser Co.
Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Lammert & Mann
Mesta Machine Co.
* Roots Co., P. H. & F. M.

Punches, Hydraulic
* Alliance Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Punches, Power
* Royersford Fdry. & Mch. Co.

Punches, Multiple
Mackintosh, Hemphill & Co.
* Wood & Co., R. D.

Punches and Dies
* Royersford Fdry. & Mch. Co.

Punching and Shearing Machines
* Alliance Machine Co.
Morgan Engineering Co.
Royersford Fdry. & Mch. Co.
Wickes Bros.
* Wood & Co., R. D.

Purifying and Softening Systems, Water
Graver Tank Works, Wm.
* Scaife & Sons Co., Wm. B.

Pyrometers, Electric
* Bristol Co.
Foxboro Co.
Scientific Materials Co.
* Taylor Instrument Cos.

Pyrometers, Optical
Scientific Materials Co.

Pyrometers, Radiation
* Taylor Instruments Cos.

Quarry Machinery
* Ingersoll-Rand Co.

Quartz Glass
Scientific Materials Co.

Racks, Cut
James Mfg. Co., D. O.

Racks, Storage, Metal
Manufacturing Equipment & Engrg. Co.

Radiators, Indirect
* Smith Co., H. B.

Radiators, Steam
* Smith Co., H. B.
Walworth Mfg. Co.

Railways, Cable and Automatic
* Hunt Co., Inc., C. W.

Railways, Industrial
* Hunt Co., Inc., C. W.
* Link-Belt Co.
Whiting Foundry Equip. Co.

Rammers, Foundry
* Ingersoll-Rand Co.

Rams, Hydraulic
* Goulds Mfg. Co.

Reamers
Greenfield Tap & Die Corp.

Receivers, Air
Graver Tank Works, Wm.
* Ingersoll-Rand Co.
* Scaife & Sons Co., Wm. B.

Recording Instruments
(See Instruments, Recording)

Refrigerating Machinery
* De La Vergne Machine Co.
* Johns-Manville Co., H. W.
* Vilter Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Refuse Destructors
(See Destructors, Refuse)

Regulators, Blower
Davis Regulator Co., G. M.

Regulators, Damper
Davis Regulator Co., G. M.
* Defender Automatic Regulator Co.

Regulators, Electric
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Regulators, Feed Water
* Almy Water Tube Boiler Co.

Regulators, Flow (Steam)
Davis Regulator Co., G. M.
Schutte & Koerting Co.

Regulators, Pressure
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
* Taylor Instrument Cos.

Regulators, Pump
(See Governors, Pump)

Regulators, Temperature
* Bristol Co.
Foxboro Co.
Sarco Co., Inc.
* Taylor Instrument Cos.

Regulators, Time
Foxboro Co.

Repairs, Emergency
* Harris-Corliss Engine & Machine Co.

Reservoirs, Aerating
* Spray Engineering Co.

Retorts, Acid
Buffalo Fdry. & Mch. Co.

Revolution Counters
(See Counters, Revolution)

Riveters, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Riveters, Pneumatic
* Ingersoll-Rand Co.

Roller Bearings
(See Bearings, Boiler)

Rolling Mill Machinery
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.

Rolls, Bending
Wickes Bros.

Rolls, Forging
Mesta Machine Co.

Rolls, Sand, Chilled and Steel
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Rolls, Rubber
* Goodrich Co., B. F.

Roofing
* Johns-Manville Co., H. W.
* Texas Co.

Roofing, Asbestos
* Johns-Manville Co., H. W.

Rope Drives
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
* Wood's Sons Co., T. B.

Rope, Hoisting
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Roebling's Sons Co., John A.

Rope, Transmission
* Caldwell & Son Co., H. W.
* Hunt Co., Inc., C. W.
* Link-Belt Co.
* Roebling's Sons Co., John A.

Rope, Wire
* Clyde Iron Works
* Roebling's Sons Co., John A.

Rubber Goods, Mechanical
* Goodrich Co., B. F.
* Jenkins Bros.
Quaker City Rubber Co.

Sand Blast Apparatus
* De La Vergne Machine Co.
* Ingersoll-Rand Co.
Lunkenheimer Co.

Saw Mill Machinery
Wickes Bros.

Screens, Revolving
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Jeffrey Mfg. Co.
* Link-Belt Co.

Screens, Shaking
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Jeffrey Mfg. Co.
* Link-Belt Co.

Screens, Traveling
* Chain Belt Co.
* Link-Belt Co.

Screw Cutting Dies
(See Dies, Screw and Thread Cutting)

Screw Machines, Hand
* Jones & Lamson Mach. Co.
* Warner & Swasey Co.

Screw Plates
Greenfield Tap & Die Corp.

Screw Steel
* Union Drawn Steel Co.

Screws, Safety Set
* Bristol Co.

Separators, Air
General Condenser Co.

Separators, Ammonia
* De La Vergne Machine Co.

Separators, Oil
* Crane Co.
* De La Vergne Machine Co.
General Condenser Co.
* National Pipe Bending Co.

Separators, Steam
* Crane Co.
General Condenser Co.
* National Pipe Bending Co.
* Pittsburgh Valve Fdry. & Const. Co.

Shafting
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Chain Belt Co.
Cumberland Steel Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
* Union Drawn Steel Co.
* Woods Sons Co., T. B.

Shapes, Cold Drawn Steel
* Union Drawn Steel Co.

Shears, Alligator
Mesta Machine Co.
Morgan Engineering Co.

Shears, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Shears, Plate
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Sheaves, Rope
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Clyde Iron Works
* Falls Clutch & Machinery Co.
* Hull Clutch Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
* Wood's Sons Co., T. B.

Sheet Mill Machinery
Mesta Machine Co.

Shelving, Metal
Manufacturing Equipment & Engrg. Co.

Shipbuilding Machinery
Morgan Engineering Co.

Shredders
Jeffrey Mfg. Co.

Silica
Scientific Materials Co.

Sirens
(See Whistles, Steam)

Sluice Gates
(See Gates, Sluice)

Smoke Recorders
Sarco Co., Inc.

Smoke Stacks and Flues
(See Stacks, Steel)

Sockets, Wire Rope
(See Wire Rope Fastenings)

Soot Blowing Systems
* Diamond Power Specialty Co.

Special Machinery
* Brown Co., A. & F.
Builders Iron Foundry
* Cowdrey Machine Works, C. H.
Defiance Machine Works
* Harris-Corliss Engine & Machine Co.
Holyoke Machine Co.
* Lammert & Mann
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Morris Co., I. P.
* Vilter Mfg. Co.
* Wood & Co., R. D.

Speed Transmissions, Variable
* Moore & White Co.

Speed Reducing Transmissions
James Mfg. Co., D. O.

Spouts, Grain
* Caldwell & Son Co., H. W.

Spray Cooling Ponds, Nozzles, etc.
(See Cooling Ponds, Nozzles, etc., Spray)

Sprays, Water
* Spray Engineering Co.

Sprinklers, Spray
* Spray Engineering Co.

Sprockets
* Caldwell & Son Co., H. W.
* Chain Belt Co.
* Hill Clutch Co.
* Link-Belt Co.

Stacks, Steel
* Bigelow Co.
Connelly Boiler Co., D.
Graver Tank Works, Wm.
Heine Safety Boiler Co.
* Keeler Co., E.

Standpipes
Graver Tank Works, Wm.

Steam Engines, Separators, Shovels, Superheaters, Traps, Turbines, etc.
(See Engines, Separators, Shovels, Superheaters, Traps, Tuprbines, etc., Steam)

Steam Specialties
* Crane Co.
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
Lunkenheimer Co.
Morehead Mfg. Co.
* Pittsburgh Valve Fdry. & Const. Co.
Sarco Co., Inc.

Steel, Alloy
* Union Drawn Steel Co.

Steel, Bright Finished
* Union Drawn Steel Co.

Steel, Cold Drawn
* Union Drawn Steel Co.

I. P. MORRIS COMPANY

PHILADELPHIA, PA.

Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

Cut shows generator room of the Turners Falls Power and Electric Company's Hydro-Electric Power Plant at Montague City, Mass. This station contains four turbines of the vertical shaft, single runner type, each of 9700 horse-power capacity. The turbines and governing equipment were designed and built by the I. P. Morris Company.

During the last twelve months, the I. P. Morris Company has received contracts for turbines aggregating 178,000 horse-power of which 157,000 horse-power represents turbines of the vertical shaft, single runner type. Inquiries for turbines requiring special design will be given every attention.

WATER WHEELS

With Connections and Complete Power Transmission

WATER WHEEL GOVERNORS GEARING
WOOD PULP AND PAPER MACHINERY
PUMPS HYDRAULIC PRESSES

SPECIAL MACHINERY TO ORDER

Holyoke Machine Company

HOLYOKE, MASS. WORCESTER, MASS.

M. T. DAVIDSON CO.

43-53 Keap St., Brooklyn, N. Y.

NEW YORK:- 154 Nassau Street,
BOSTON:- 32 Oliver Street,
PHILADELPHIA:- Real Estate Trust Building,
CHICAGO:- F. H. Schinneer, 549 W. Washington Street,
ROCHESTER:- Alden L. Covill, Granite Building,
BALTIMORE:- Richard Morton, Equitable Building

High Grade Economical Pumps For all Services

SURFACE AND JET CONDENSERS

ONE of the largest collections of engineering literature in the world is the Engineering Library in the Engineering Societies Building, 29 West 39th Street, New York.

It comprises 65,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 1000 technical journals and magazines are regularly received, including practically every important engineering journal in the world in the mechanical, electrical and mining fields.

The library is open from 9 a. m. to 10 p. m., with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

LAMMERT & MANN

ENGINEERS - MACHINISTS

Wood and Walnut Sts. Chicago, Ill.

MANUFACTURERS OF

Rotary Vacuum Pumps for highest possible Dry Vacuum

Rotary Blowers—Centrifugal Pumps

Contract Work and Builders of Special Machinery

SEND US YOUR BLUE PRINTS

Steel, Cold Rolled
Cumberland Steel Co.
* Union Drawn Steel Co.

Steel, Nickel
* Union Drawn Steel Co.

Steel, Open Hearth
* Union Drawn Steel Co.

Steel, Vanadium
* Union Drawn Steel Co.

Steering Engines
(See Engines, Steering)

Steel Plate Construction
* Bigelow Co.
Connelly Boiler Co., D.
Graver Tank Works, Wm.
Heine Safety Boiler Co.
* Keeler Co., E.
* Wood & Co., R. D.

Stills
Connelly Boiler Co., D.
Graver Tank Works, Wm.

Stocks and Dies
Greenfield Tap & Die Corp.

Stokers
American Engineering Co.
* Babcock & Wilcox Co.
Combusion Engineering Corp.
* Green Engineering Co.
* Murphy Iron Works
Riley Stoker Co., Ltd., Sanford
Westinghouse Elec. & Mfg. Co.
Wetzel Mechanical Stoker Co.

Stokers, Chain Grate
* Babcock & Wilcox Co.
Combustion Engineering Corp.
* Green Engineering Co.
Westinghouse Elec. & Mfg. Co.

Stokers, Overfeed
* Murphy Iron Works
Westinghouse Elec. & Mfg. Co.
Wetzel Mechanical Stoker Co.

Stokers, Underfeed
American Engineering Co.
Combustion Engineering Corp.
Riley Stoker Co., Ltd., Sanford
Westinghouse Elec. & Mfg. Co.

Stools and Chairs, Metal
Manufacturing Equipment & Engrg. Co.

Strainers, Water
Davidson Co., M. T.
Golden-Anderson Valve Specialty Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.

Strainers, Water, Traveling
* Chain Belt Co.
* Link-Belt Co.

Structural Steel Work
Toledo Bridge & Crane Co.

Sugar Machinery
Hooven, Owens, Rentschler Co.
* Wood & Co., R. D.

Superheaters, Air
Power Specialty Co.

Superheaters, Steam
* Babcock & Wilcox Co.
Heine Safety Boiler Co.
Power Specialty Co.
Superno Co., Inc.

Switchboards
* General Electric Co.
Sprague Electric Works
Westinghouse Elec. & Mfg. Co.

Switches, Electric
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Synchronous Converters
(See Converters, Synchronous)

Syphons (Steam-Jet)
Schutte & Koerting Co.

Tachometers
* Bristol Co.
Foxboro Co.
* Veeder Mfg. Co.
* Weston Electrical Instrument Co.

Tackle Blocks
(See Blocks, Tackle)

Tank Work (Air, Gas, Oil and Water)
* Bigelow Co.
Connelly Boiler Co., D.
Graver Tank Works, Wm.
Heine Safety Boiler Co.
* Keeler Co., E.
* Scaife & Sons Co., Wm. B.
* Wood & Co., R. D.

Tanks, Car
Connelly Boiler Co., D.
Graver Tank Works, Wm.

Tanks, Copper
* Scaife & Sons Co., Wm. B.

Tanks, Storage
Connelly Boiler Co., D.
Graver Tank Works, Wm.
* Scaife & Sons Co., Wm. B.

Tanks, Welded
Graver Tank Works, Wm.
* Scaife & Sons Co., Wm. B.

Taps and Dies
Greenfield Tap & Die Corp.

Teloscopic Oilers
(See Oilers, Teloscopic)

Temperature Regulators
(See Regulators, Temperature)

Testing Laboratories, Electrical
Electrical Testing Laboratories, Inc.

Thermometers
* Ashton Valve Co.
* Bristol Co.
* Defender Automatic Regulator Co.
Foxboro Co.
Scientific Materials Co.
* Taylor Instrument Cos.

Thermometers, Distance
* Bristol Co.
Foxboro Co.
* Taylor Instrument Cos.

Thread Cutting Tools
* Jones & Lamson Machine Co.
Greenfield Tap & Die Corp.

Time Controllers
(See Regulators, Time)

Time Recorders
* Bristol Co.
Foxboro Co.

Tipples, Steel
Jeffrey Mfg. Co.
* Link-Belt Co.

Tools, Brass-Working Machine
* Warner & Swasey Co.

Tools, Machinist's Small
* Atlas Ball Co.

Tools, Pipe Fitters
Walworth Mfg. Co.

Torches, Hand
* Best, W. N.

Track, Industrial
* Hunt Co., Inc., C. W.
Northern Engineering Works
Whiting Foundry Equip. Co.

Tramrail Systems, Overhead
Box & Co., Alfred
Brown Hoisting Machinery Co.
* Ford Chain Block & Mfg. Co.
* Link-Belt Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.
Sprague Electric Works
Whiting Foundry Equip. Co.

Tramways, Bridge
Brown Hoisting Machinery Co.
* Hunt Co., Inc., C. W.
* Link-Belt Co.
Toledo Bridge & Crane Co.

Tramways, Wire Rope
* Clyde Iron Works
* Roebling's Sons Co., John A.
* Lidgerwood Mfg. Co.

Transfer Tables
Whiting Foundry Equip. Co.

Transformers, Electric
* Crocker-Wheeler Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Transmission Machinery
(See Power Transmission Machinery)

Traps, Condenser
Morehead Mfg. Co.

Traps, Return
* Crane Co.
General Condenser Co.
Morehead Mfg. Co.

Traps, Steam
* Crane Co.
Davis Regulator Co., G. M.
General Condenser Co.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Morehead Mfg. Co.
* Pittsburgh Valve Fdry. & Const. Co.
Sarco Co., Inc.
Schutte & Koerting Co.

Traps, Vacuum
* Crane Co.
General Condenser Co.
Morehead Mfg. Co.
Sarco Co., Inc.

Trolleys, Mono-Rail
(See Tramrail Systems, Overhead)

Trucks, Electric
* Hunt Co., Inc., C. W.

Trucks, Mill
* American Vulcanized Fibre Co.

Tube Cleaners, Boiler
* Johns-Manville Co., H. W.

Tubes, Boiler
Parkesburg Iron Co.

Tubes, Charcoal Iron
Parkesburg Iron Co.

Tubing, Fibre
* American Vulcanized Fibre Co.

Tubing, Rubber
* Goodrich Co., B. F.
Quaker City Rubber Co.

Tumbling, Barrels
Northern Engineering Works
* Royersford Foundry & Mch. Co.
Whiting Foundry Equip. Co.

Turbines, Hydraulic
Holyoke Machine Co.
* Morris Co., I. P.

Turbines, Steam
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Turbo-Generators
* General Electric Co.
Westinghouse Elec. & Mfg. Co.

Turntables
* Hunt Co., Inc., C W
* Link-Belt Co.
Northern Engineering Works
Whiting Foundry Equip Co.

Turret Machines
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co.
* Warner & Swasey Co.

Turret Machines, Vertical
King Machine Tool Co.

Unions
* Crane Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.

Uniflow Engines
(See Engines, Uniflow)

Underfeed Stokers
(See Stokers, Underfeed)

Unloaders, Air Compressor
Yarnall-Waring Co.

Unloaders, Ballast
* Lidgerwood Mfg. Co.

Vacuum Dryers, Pans, Pumps, Traps, etc.
(See Pans, Pumps, Traps, etc., Vacuum)

Vacuum Drying Apparatus
Buffalo Fdry. & Mch. Co.

Valve Balls
* Goodrich Co., B. F.

Valve Boxes
Ludlow Valve Mfg. Co.
* Wood & Co., R. D.

Valve Discs
* American Vulcanized Fibre Co.
* Goodrich Co., B. F.
* Jenkins Bros.
Quaker City Rubber Co.

Valves, Air, Automatic
Davis Regulator Co., G. M.
* Jenkins Bros.
* Smith Co., H. B.

Valves, Air Relief
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Schutte & Koerting Co.

Valves, Altitude
Golden-Anderson Valve Specialty Co.

Valves, Ammonia
* Crane Co.
* De La Vergne Machine Co.
* Jenkins Bros.
* Homestead Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
* Vilter Mfg. Co.
Walforth Mfg. Co.

Valves, Back Pressure
* Crane Co.
Davis Regulator Co., G. M.
* Jenkins Bros.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walforth Mfg. Co.

Valves, Balanced
* Crane Co.
Davidson Co., M. T.
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
* Homestead Valve Mfg. Co.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Schutte & Koerting Co.
Walsworth Mfg. Co.

Valves, Blowoff
Ashton Valve Co.
* Crane Co.
Golden-Anderson Valve Specialty Co.
* Homestead Valve Mfg. Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Walworth Mfg. Co.
Yarnall-Waring Co.

Valves, Butterfly
* Crane Co.
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.

Valves, Check
* Crane Co.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Exhaust Relief
* Crane Co.
Davidson Co., M. T.
Davis Regulator Co., G. M.
* Jenkins Bros.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walsworth Mfg. Co.

Valves, Float
* Crane Co.
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
* Homestead Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.

Valves, Foot
* Crane Co.
Ludlow Valve Mfg. Co.
* Pittsburgh Valve Fdry. & Const. Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Gate
* Crane Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Globe, Angle and Cross
* Crane Co.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Walworth Mfg. Co.

Valves, Hose
* Crane Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkerheimer Co.
Nelson Valve Co.
Walworth Mfg. Co.

Valves, Hydraulic
* Crane Co.
Davidson Co., M. T.
* Homestead Valve Mfg. Co.
Lunkenheimer Co.
Morgan Engineering Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.
Yarnall-Waring Co.

Valves, Hydraulic Operating
Lunkenheimer Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
* Wood & Co., R. D.

Valves, Non-Return
* Crane Co.
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Plate, for Blowing Engines
Mesta Machine Co.

Valves, Plug
Golden-Anderson Valve Specialty Co.
* Homestead Valve Mfg. Co.

Valves, Pop Safety
* Ashton Valve Co.
* Crane Co.
Lunkenheimer Co.

Valves, Pump
* American Vulcanized Fibre Co.
* Goodrich Co., B. F.
Goulds Mfg. Co.
* Jenkins Bros.
* Johns-Manville Co., H. W.
Quaker City Rubber Co.

Valves, Radiator
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.
Walworth Mfg. Co.

Valves, Reducing
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.

Valves, Regulating
* Crane Co.
Davis Regulator Co., G. M.
Golden-Anderson Valve Specialty Co.
Lunkenheimer Co.

Valves, Relief (Water)
* Ashton Valve Co.
* Crane Co.
Golden-Anderson Valve Specialty Co.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
* Wood & Co., R. D.

Valves, Safety
* Crane Co.
* Jenkins Bros.
Lunkenheimer Co.

Valves, Steel (Superheated Steam)
* Crane Co.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Stop and Check
(See Valve, Non-Return)

Valves, Throttle
* Crane Co.
Golden-Anderson Valve Specialty Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
Lunkenheimer Co.
Nelson Valve Co.
* Pittsburgh Valve Fdry. & Const. Co.
* Richardson-Phenix Co.
Schutte & Koerting Co.

Ventilating and Heating Apparatus
(See Heating and Ventilating Apparatus)

Voltmeters
* Bristol Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.
* Weston Electrical Instrument Co.

Vulcanizers
* Bigelow Co.

Wash Bowls
Manufacturing Equipment & Engrg. Co.

Washers, Rubber
* Goodrich Co., B. F.
Quaker City Rubber Co.

Washers, Leather
* Schieren Co., Chas. A.

Water Cinder Mills
(See Mills, Cinder, Water)

Water Circulators, Filters, Gages, Heaters, Meters, Strainers, etc.
(See Circulators, Filters, Gages, Heaters, Meters, Strainers, etc., Water)

Water Columns
* Ashton Valve Co.
Lukenheimer Co.
Walworth Mfg. Co.

Water Columns, Railway
Golden-Anderson Valve Specialty Co.

Water Purifying Plants
* Scaife & Sons Co., Wm. B.

Water Softeners and Purifiers
Graver Tank Works, Wm.
* Scaife & Sons Co., Wm. B.

Water Tube Boilers
(See Boilers, Water Tube)

Water Wheels, Turbine
Holyoke Machine Co.
* Morris Co., I. P.

Waterproofing Materials
* Johns-Manville Co., H. W.
* Texas Co.

Wattmeters
* Bristol Co.
* General Electric Co.
Westinghouse Elec. & Mfg. Co.
* Weston Electrical Instrument Co.

Welding, Oxy-Acetylene
* Pittsburgh Valve Fdry. & Const. Co.

Wheels, Polishing, Paper
Rockwood Mfg. Co.

Whistles, Steam
* Ashton Valve Co.
* Brown Co., A & F.
* Crane Co.
Lunkenheimer Co.
Walworth Mfg. Co.

Winches
Brown Hoisting Machinery Co.
* Lidgerwood Mfg. Co.

Wire, Brass and Copper
* Roebling's Sons Co., John A.

Wire, Flat
* Roebling's Sons Co., John A.

Wire, Iron and Steel
* Roebling's Sons Co., John A.

Wire and Cables, Electrical
* General Electric Co.
* Roebling's Sons Co., John A.

Wire Cloth
* Caldwell & Son Co., H. W.

Wire Rope
(See Rope, Wire)

Wire Rope Fastenings
* Lidgerwood Mfg. Co.
* Roebling's Sons Co., John A.

Wire Rope Slings
* Roebling's Sons Co., John A.

Wire Specialties
* Roebling's Sons Co., John A.

Wiring Devices
* General Electric Co.

Wood-working Machinery
Defiance Machine Works

Work Benches
(See Benches, Work)

Wrenches
* Greene, Tweed & Co.
* Roebling's Sons Co., John A.
Walworth Mfg. Co.

Wrenches, Tap
Greenfield Tap & Die Corp.

Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1916 Volume.

Sold the world over!

The New Book

DIESEL ENGINES

(Marine and Stationary)

By A. H. GOLDINGHAM *M. A. S. M. E. M. I. Mech. E., Etc.*

Extracts from Book Reviews

"The present work is essentially a practical one, concise and well illustrated."—*Jl. Am. Soc. of Mech. Eng.*

"The engineering public will welcome this volume . . . It gives in concise form all useful, available information on the design, installation and operation of these machines . . . The book will be found interesting to all those who are constructing or operating the engine."—*The Iron Age.*

"The Author has covered much ground and dealt with the representative makes of both Marine and Stationary Diesel Engines."—*Power.*

"A handy book for students and engineers . . . Details of construction are fully covered . . . comprehensive in explanations and copiously illustrated."—*Proc. U.S. Naval Inst., Washington, D. C.*

Cloth, Price $3.00

Have you ordered your copy?

Oil Engines (4th Ed.)

(Design and Construction)

By the same Author

Full directions for constructing, erecting, testing, installing and operating. 308 pages, 142 illustrations and 48 fine page plates.
"A thoroughly practical and comprehensive treatise."

Cloth, Price $2.60, Postpaid

The Gas Engine

In Principle and Practice

By the same Author

Cloth, Price 75c.

Buchanan's Tables of Squares

Gives square of every foot, inch and sixteenth of an inch between one-sixteenth of an inch and fifty feet. *Eleventh* Edition. Limp Cloth.

Price $1.10, Postpaid

AEROPLANES

in Gusts, Soaring Flight and the Stability of the Aeroplane, by S. L. Walkden. 2nd Edition. Greatly Enlarged. 280 pp., 4 plates, 78 illustrations. A live book on a live subject.

Cloth, Price $4.20, Postpaid

SPON & CHAMBERLAIN

123 Liberty Street, New York

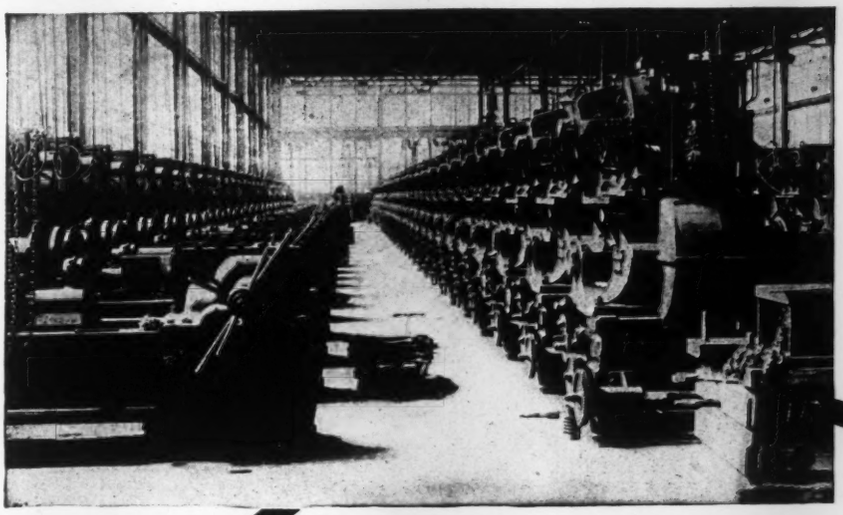
E. & F. N. SPON, Ltd., London, Eng.

ALPHABETICAL LIST OF ADVERTISERS

See Pages 50-63 for Classified List of Mechanical Equipment

	Page
Ahlberg Bearing Co. 2636 Michigan Ave., Chicago, Ill.	38
***Alliance Machine Co.** Alliance, O.	44
***Almy Water Tube Boiler Co.** Providence, R. I.	—
American Cast Iron Pipe Co. Birmingham, Ala.	30
American Engineering Co. Philadelphia, Pa.	21
American Lead Pencil Co. 211 Fifth Ave., N. Y. C.	—
***American Vulcanized Fibre Co.** 565-575 Equitable Bldg., Wilmington, Del.	55
***Ashton Valve Co.** 271 Franklin St., Boston, Mass.	33
***Atlas Ball Co.** 206 Glenwood Ave., Philadelphia, Pa.	8
***Babcock & Wilcox Co.** 85 Liberty St., N. Y.	17
Bacharach Industrial Instrument Co. 14 Wood St., Pittsburgh, Pa.	33
***Bailey Meter Co.** 141 Milk St., Boston, Mass.	32
***Ball Engine Co.** Erie, Pa.	—
***Best, Inc., W. N.** 11 Broadway, N. Y. C.	49
***Bigelow Co.** 76 River St., New Haven, Conn.	17
Box & Co., Alfred. Philadelphia, Pa.	42
***Bristol Co.** Waterbury, Conn.	67
***Brown Co., A. & F.** 79 Barclay St., N. Y. C.	36
Brown Hoisting Machinery Co. Cleveland, O.	45
Buffalo Foundry & Machine Co. 37 Winchester Ave., Buffalo, N. Y.	55
Builders Iron Foundry. Providence, R. I.	32
***Caldwell & Son Co., H. W.** 17th St. & Western Ave., Chicago, Ill.	42
Cast Iron Pipe Publicity Bureau. 1 Broadway, N. Y. C.	30
***Central Foundry Co.** 90 West St., N. Y.	29
***Chain Belt Co.** 734 Park St., Milwaukee, Wis.	25
Clow & Sons, James B. Chicago, Ill.	30
***Clyde Iron Works.** Duluth, Minn.	44
Colleges, Engineering	4, 5
Combustion Engineering Corp'n. 11 Broadway, N. Y.	18
Connelly Boiler Co., D. Ivanhoe Road & N. Y. C. & St. L. R. R., Cleveland, O.	14
***Cowdrey Machine Works, C. H.** Fitchburg, Mass.	47
***Crane Co.** 836 So. Michigan Ave., Chicago, Ill.	31
Crescent Mfg. Co. Scottdale, Pa.	14
***Crocker-Wheeler Co.** Ampere, N. J.	14
Cumberland Steel Co. Cumberland, Md.	49
Davidson Co., M. T. 43-53 Keap St., Brooklyn, N. Y.	61
Davis Regulator Co., G. M. 439 Milwaukee Avenue, Chicago, Ill.	28
***De La Vergne Machine Co.** 1123 E. 138th St., N. Y. C.	—
***Defender Automatic Regulator Co.** Sixth & Locust Sts., St. Louis, Mo.	34
Defiance Machine Works. Defiance, Ohio.	49
***Diamond Power Specialty Co.** Detroit, Mich.	22
***Doehler Die Casting Co.** Court & Ninth Sts., Brooklyn, N. Y.	48
Donaldson Iron Co. Emaus Lehigh Co., Pa.	30
Eastern Machinery Co. New Haven, Conn.	42
***Edge Moor Iron Co.** Edge Moor, Del.	16
Electro Dynamic Co. Bayonne, N. J.	14
Engineers, Consulting	2, 3, 4
***Erie City Iron Works.** Erie, Pa.	15
Fafnir Bearing Co. New Britain, Conn.	40
***Falls Clutch & Mchy. Co.** Cuyahoga Falls, O.	36
***Fellows Gear Shaper Co.** Springfield, Vt.	47
***Flexible Steel Lacing Co.** 522 So. Clinton St., Chicago, Ill.	57
***Ford Chain Block & Mfg. Co.** Oxford St., Philadelphia, Pa.	46
Foxboro Co. Foxboro, Mass.	33
***Fulton Iron Works.** 1259 Delaware Ave., St. Louis, Mo.	12
***General Electric Co.** Schenectady, N. Y.	53
***Gilbert & Barker Mfg. Co.** Springfield, Mass.	48
***Gilmer Co., L. H.** Philadelphia, Pa.	38
Glamorgan Pipe & Foundry Co. Lynchburg, Va.	30
Golden-Anderson Valve Specialty Co. 1228 Fulton Bldg., Pittsburgh, Pa.	27
***Goodrich Co., B. F.** Akron, O.	41
Goulds Mfg. Co. 78 West Falls St., Seneca Falls, N. Y.	59
Graver Tank Works, Wm. 4854 Tod Ave., East Chicago, Ind.	22
***Green Engineering Co.** East Chicago, Ind.	19
***Greene, Tweed & Co.** 109 Duane St., N. Y. C.	14
Greenfield Tap & Die Corp'n. Greenfield, Mass.	49
***Gwilliam Co.** 253 W. 58th St., N. Y. C.	67
***Harris-Corliss Engine & Machine Co.** Providence, R. I.	13
Heald Machine Co. Worcester, Mass.	—
Heine Safety Boiler Co. 2465 E. Marcus Ave., St. Louis, Mo.	16
***Hill Clutch Co.** Cleveland, O.	36
Holyoke Machine Co. Holyoke, Mass.	61
***Homestead Valve Mfg. Co.** Pittsburgh, Pa.	—
Hooven, Owens' Rentschler Co. Hamilton, O.	12
***Hunt Co., Inc., C. W.** West New Brighton, N. Y.	22
***Ingersoll-Rand Co.** 11 Broadway, N. Y. C.	48
James Mfg. Co., D. O. 1122 W. Monroe St., Chicago, Ill.	36
Jeffrey Mfg. Co. 904 N. 4th St., Columbus, O.	42
***Jenkins Bros.** 80 White St., N. Y. C.	29
***Johns-Manville Co., H. W.** 41st and Madison Ave., N. Y. C.	9
***Jones & Lamson Machine Co.** Springfield, Vt.	10, 11
***Keeler Co., E.** Williamsport, Pa.	16
King Machine Tool Co. Cincinnati, O.	—
***Lammert & Mann.** Wood & Walnut Sts., Chicago, Ill.	61
Le Blond Machine Tool Co., R. K. Cincinnati, O.	47
***Lidgerwood Mfg. Co.** 96 Liberty St., N. Y. C.	44
***Link-Belt Co.** Chicago, Ill.	24
Locomotive Pulverized Fuel Co. 30 Church St., N. Y. C.	19
Ludlow Valve Mfg. Co. Troy, N. Y.	28
Lunkenheimer Co. Cincinnati, O.	26
Lynchburg Foundry Co. Lynchburg, Va.	30
Mackintosh, Hemphill & Co. Pittsburg, Pa.	14
Manufacturing Equip. & Engrg. Co. 209 Washington St., Boston, Mass.	57
Massillon Iron & Steel Co. Massillon, Ohio.	30
Mesta Machine Co. Pittsburgh, Pa.	—
***Moore & White Co.** Philadelphia, Pa.	37
Morehead Mfg. Co. Dept. 7, Detroit, Mich.	34
Morgan Engineering Co. Alliance, O.	42
***Morris Co., I. P.** Philadelphia, Pa.	61
***Morris Machine Works.** Baldwinsville, N. Y.	59
***Murphy Iron Works.** Detroit, Mich.	19
***National Meter Co.** 84 Chambers St., N. Y. C.	13
***National Pipe Bending Co.** New Haven, Conn.	23
Nelson Valve Co. 7612-20 Queen St., Chestnut Hill, Phila.	—
New Process Gear Corp'n. Syracuse, N. Y.	38
***Norma Co. of America.** 1790 Broadway, N. Y. C.	39
Northern Engineering Works. Detroit, Mich.	43
Orton & Steinbrenner Co. Chicago, Ill.	44
Otto Gas Engine Works. 3219 Walnut St., Philadelphia, Pa.	13
Parkesburg Iron Co. Parkersburg, Pa.	17
***Pickering Governor Co.** Portland, Conn.	14
***Pittsburgh Valve Fdry. & Const. Co.** 26th & A. V. R. R., Pittsburgh, Pa.	—
Power Specialty Co. 111 Broadway, N. Y. C.	—
***Precision Instrument Co.** East Fort & Beaubein Sts., Detroit, Mich.	33
Profess'nal and Educational Directory	1
Quaker City Rubber Co. 629 Market St., Philadelphia, Pa.	67
***Richardson-Phenix Co.** 129 Reservoir Ave., Milwaukee, Wis.	51
Riley Stoker Co., Ltd., Sanford. Worcester, Mass.	19
Rockwood Mfg. Co. 1923 English Ave., Indianapolis, Ind.	—
***Roebling's Sons Co., John A.** Trenton, N. J.	39
***Roots Co., P. H. & F. M.** Connersville, Ind.	—
***Royersford Foundry & Machine Co.** 60 N. 5th St., Philadelphia, Pa.	40
Sarco Co., Inc. Woolworth Bldg., N. Y. C.	31
***Scaife & Sons Co., Wm. B.** 221 First Ave., Pittsburgh, Pa.	22
***Schieren Co., Chas. A.** 25 Ferry St., N. Y. C.	66
Schutte & Koerting Co. 1237-59 N. 12th St., Philadelphia, Pa.	19
Scientific Materials Co. 711-719 Forbes St., Pittsburgh, Pa.	67
***Shepard Electric Crane & Hoist Co.** Montour Falls, N. Y.	43
***Smith Co., H. B.** Westfield, Mass.	—
Smith Gas Engineering Co. Lexington, O.	16
Sonneborn Sons, Inc., L. 264 Pearl St., N. Y. C.	55
Spon & Chamberlain. 123 Liberty St., N. Y. C.	63
Sprague Electric Works. 527-531 W. 34th St., N. Y. C.	44
***Spray Engineering Co.** 93 Federal St., Boston, Mass.	26
***Springfield Boiler & Mfg. Co.** Springfield, Ill.	15
Standard Cast Iron Pipe & Fdy. Co. Bristol, Pa.	30
Superno Co., Inc. 52 Broadway, N. Y. C.	17
***Taylor Instrument Cos.** Rochester, N. Y.	34
***Texas Co.** 17 Battery Place, N. Y. C.	35
Toledo Bridge & Crane Co. Toledo, O.	—
***Union Drawn Steel Co.** Beaver Falls, Pa.	49
U. S. Cast Iron Pipe & Foundry Co. Philadelphia, Pa.	30
***Veeder Mfg. Co.** 16 Sargeant St., Hartford, Conn.	34
***Vilter Manufacturing Co.** 1070-1088 Clinton St., Milwaukee, Wis.	—
Walworth Mfg. Co. Boston, Mass.	28
***Warner & Swasey Co.** Cleveland, O.	9
Weimer Machine Works Co. Lebanon, Pa.	—
Westinghouse Electric & Mfg. Co. East Pittsburgh, Pa.	65
***Weston Electrical Instrument Co.** Newark, N. J.	34
Wetzel Mechanical Stoker Co. 30 Church St., N. Y. C.	20
Whiting Foundry Equipment Co. Harvey, Ill.	43
***Wickes Boiler Co.** Saginaw, Mich.	16
Wickes Bros. Saginaw, Mich.	57
***Wood & Co., R. D.** Philadelphia, Pa.	59
***Wood's Sons Co., T. B.** Chambersburg, Pa.	36
Yale & Towne Mfg. Co. 9 E. 40th St., N. Y. C.	46
Yarnall-Waring Co. 7612-20 Queen St., Philadelphia, Pa.	32

Catalogue data of firms marked * appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1916 Volume



W
WESTINGHOUSE ELECTRIC

An Extraordinary Motor Installation

The above picture shows a modern plant where Westinghouse Type SK Motors and Type C Automatic Control play a leading part in securing this ideal plant arrangement.

259 Westinghouse Type SK Motors

are installed driving machine tools. A total absence of belts speaks for individual motor-drive,—increased production; no transmission losses; less power cost; no delays due to line shaft failure; better work due to cleaner and brighter plant conditions; all these are reasons why you should specify Westinghouse Type SK Motors for your machine tools.

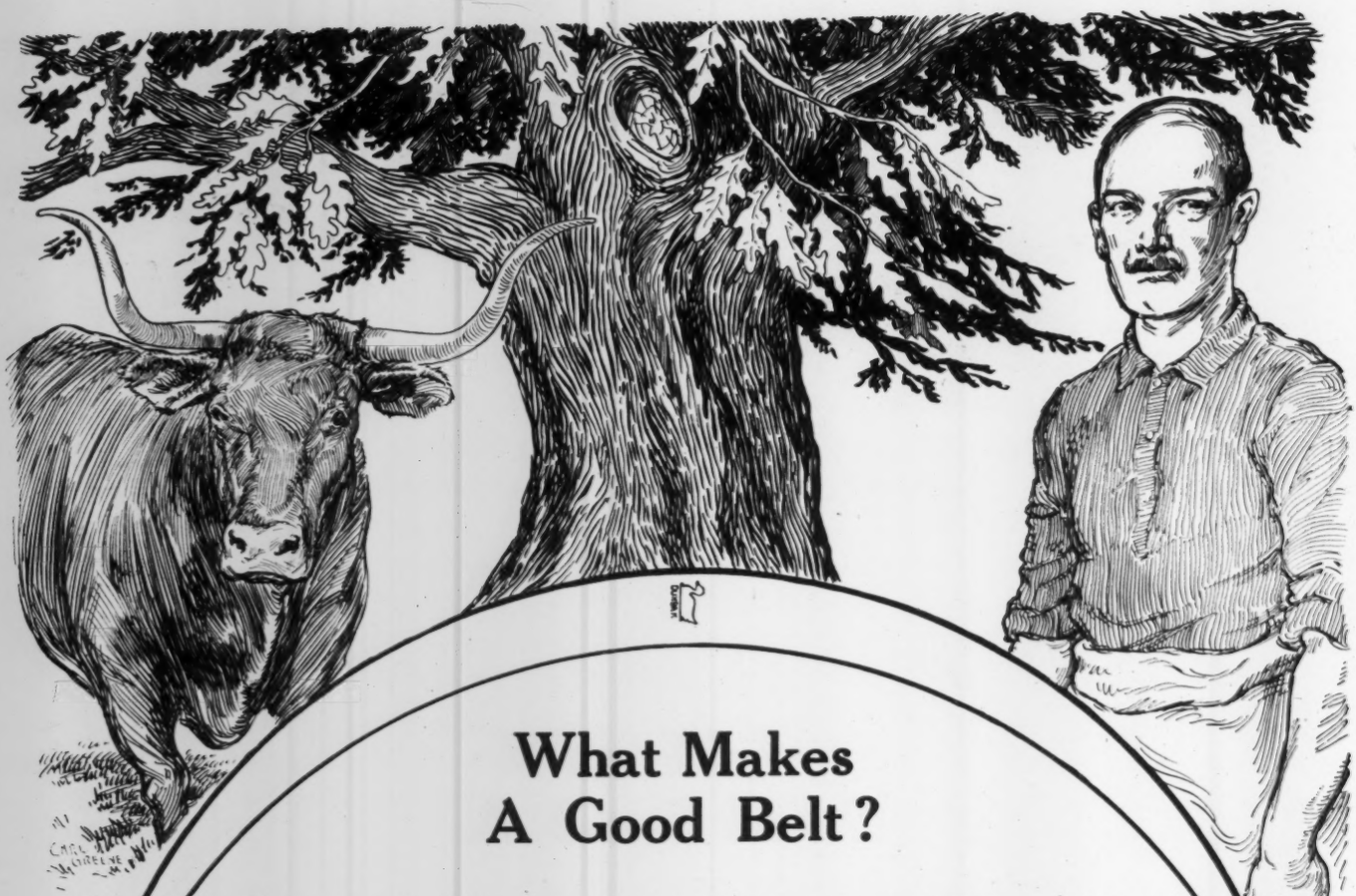
Westinghouse Type C Automatic Controllers

are mounted on head stock of the lathes. The control is within easy reach of the operator. All movements of the lathe are under his complete control. A push button starts and stops the motor. Westinghouse Type C Automatic Control is Simple, Reliable and Easy to operate, and together with Westinghouse Type SK Motors. makes a Winning Combination.

Send for Book 3042. Containing the story of Motor-Driven Machine Tools.

Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.

Westinghouse



What Makes A Good Belt?

These are the three links in the chain of Duxbak Belt making. First, the backbone section from the hide of a full-grown, vigorous steer; Second, pure liquor from the bark of the oak tree; Third, the skill and knowledge of experienced workmen.

The third link is a mighty important factor. It takes years of apprenticeship and practical work to learn how to take the stretch out of a belt without impairing its strength—or how to lay the laps so they will be uniform in thickness and pliability.

DUXBAK Belting is just as carefully made as if each belt was to be used on only the most difficult drive known to factory practice. The result is that any **DUXBAK** you buy will give you complete satisfaction.

DUXBAK BELTING
TRADE MARK
Reg. U. S. Pat. Office.

Chas. A. Schieren Company
ESTABLISHED 1868
TANNERS,
BELT MANUFACTURERS

NEW YORK, - - 25 Ferry Street

Denver.....1752 Arapahoe St.
Boston.....641-643 Atlantic Ave., Opp. So. Sta.
Chicago.....128 West Kinzie St.
Philadelphia.....226 North Third St.
Pittsburgh.....337 2nd Ave.
Seattle.....305 First Ave. So.
Petersburg, Va.....122 Shore St.
New Orleans, La.....404-406 Canal St.
The Texas Chas. A. Schieren Co., Inc., 205 S. Market St., Dallas, Tex.

Oak Leather Tanneries. Bristol, Tenn.

DUXBAK

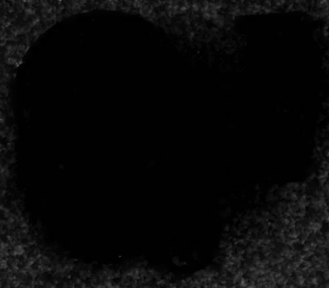
At Your Service

The benefit of more than 30 years' experience in solving transmission, conveyor and elevator belt problems is at your command without cost or obligation.

Add to your library our 180-page, illustrated catalogue of Mechanical Rubber Goods—free, of course.

Quaker City Rubber Co.

PHILADELPHIA 619 Market St. CHICAGO 182 W. Lake St. PITTSBURGH 211 Wood St. NEW YORK 207 Fulton St.



ATMOSPHERIC TEMPERATURE
ACCURATELY RECORDED

Continuous night and day records of the outdoor temperature for a whole week can be made on one chart. The sensitive bulb enclosed in the lattice box is installed out-of-doors and the recording instrument located indoors.

TRADE MARK

BRISTOL'S

REG. U. S. PAT. OFFICE

RECORDING THERMOMETERS

have been adapted to a variety of uses and applications by designing suitable fittings for installing the sensitive bulbs at the point where the temperature is to be measured.

Write for Catalog C-1100

THE BRISTOL CO., WATERBURY, CONN.

Branch Offices

BOSTON CHICAGO PITTSBURGH NEW YORK SAN FRANCISCO

SCIMATCO

Spring Type Pressure Measurographs

Made in diaphragm spring type for pressures from 1/16" of water to 15 lbs. per square inch, and in Bourdon spring type for pressures from 5 lbs. to 250 lbs. per square inch. There are ten different ranges.

These instruments have been put in service under various conditions and have satisfied every requirement of reliability and accuracy.

We have a very interesting price proposition to offer the early buyers. Tell us your requirements and let us show you what we can save you on your installation. Write to-day.

SCIENTIFIC MATERIALS CO., PITTSBURGH, PA.

Ball and Roller Bearings

1. Annular Ball Bearing, Single Row.
2. Annular Ball Bearing, Double Row.
3. Ball Bearing Shears.
4. Ball Thrust Bearing, Collar Type.
5. Ball Thrust Bearing, with [illegible] [illegible].
6. Ball Thrust Bearing, [illegible] [illegible].
7. Ball Thrust Stop Bearing.
8. Bronze Ball.
9. Journal Roller Bearing.
10. Journal Roller Bearing, with [illegible] [illegible].
11. [illegible] [illegible] [illegible].
12. [illegible] [illegible] [illegible].
13. Radial Bearing.
14. Roller Thrust Bearing.
15. Steel Ball.
16. Taper Roller Bearing.
17. Taper Roller Bearing, [illegible] [illegible].
18. Thrust Bearing [illegible] [illegible].

[illegible]

THE NEW DEPARTURE SERVICE STATION

THE GWILLIAM COMPANY

[illegible]

THE JOURNAL OF
THE AMERICAN SOCIETY
OF
MECHANICAL ENGINEERS
29 West 39th Street, New York